

TM 9-1860

1 45 WAR DEPARTMENT

TECHNICAL MANUAL



ORDNANCE MAINTENANCE STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

DECEMBER 3, 1942

ORDNANCE MAINTENANCE

STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

Prepared under the direction of the
Chief of Ordnance

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*The instructions contained in this manual supersede:

1. OFSB 4-1, "Maintenance of Materiel in the Hands of Troops," March 15, 1938, paragraph 6 a through 6 d.
2. Supplement to SNL N-9, "Essential Data—Notes on Materiel," January 1, 1939, paragraphs 1 through 52.
3. Service handbook, W.D. 1100, "Pressure Gage Outfits for Determining Pressures in Cannon."

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES**

PART ONE

STAR-GAGING EQUIPMENT

Section I

INTRODUCTION

	Paragraph
Scope	1

1. SCOPE.

a. This manual is published for the information and guidance of ordnance maintenance personnel. It contains detailed instructions for use, disassembly, assembly, care and preservation of star gages and pressure gages and detailed instructions for making gutta-percha and plaster of paris impressions. Descriptive matter and illustrations are included to aid in providing a complete working knowledge of star gages, pressure gages and gutta-percha and plaster of paris impressions.

Section II

GENERAL DESCRIPTION AND FUNCTIONING

	Paragraph
Description of gages	2
Functioning	3
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2. DESCRIPTION OF GAGES.

a. General. Star gages are instruments to measure accurately bore diameters. They are used chiefly to measure: (1) the normal or abnormal wear and erosion of bores and chambers of cannon to determine their remaining accuracy life and their fitness for use and (2) to measure pits, burs, etc., which occasionally form in the bore of cannon. Star gages are used during the manufacture of cannon to determine the interior diameters of mating components such as tubes, jackets, hoops, liners, etc. They may also be used to measure accurately the inside diameters of recoil cylinders, recuperator cylinders and other objects of circular bore.

b. Types.

(1) Several types of star gage are used to measure the interior diameter of objects of circular bore. The lever-type is the standard star gage for use in the field, at base arsenals and at manufacturing plants. The assembly, disassembly, operation and care and preservation of this type are described in detail in this Manual.

(2) The micrometer handle gage is of earlier design than the lever gage. At present, it is used only at the Aberdeen Proving Ground. This gage is similar to the lever gage, the main difference being in the method of applying the force necessary to move the measuring points.

(3) Other gages for measuring interior diameters include the spring-actuated dial indicator type, the air-pressure type and the air-flow type. At present, these gages are used chiefly at manufacturing plants. The use, operation and care of a spring-actuated dial indicator gage are described in section VIII.

c. Lever-type Star Gages (fig. 1). There are four sizes of lever-type star gages. Their approximate ranges of measurement are summarized on page 5.

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Figure 1—Exterior View of Lever-type Star Gage Assembled for Star-gaging (2-inch Gage with 3-point Head)

GENERAL DESCRIPTION AND FUNCTIONING

Star Gage	Cannon Bore for Which Used
0.75-inch ¹	20-mm
1.35-inch	37-mm to 57-mm ²
2-inch	75-mm to 155-mm ²
5.75-inch	8-inch to 16-inch ³

All four gages are constructed in an essentially similar manner, having a head tube with head assembled on one end and a lever-operated handle on the other. The measuring points are mounted in the head. One or more extension staves may be installed between the head tube and the lever-operated handle, according to the length of the cannon bore to be measured.

3. FUNCTIONING.

a. A schematic view of a 3-point lever-type star gage is shown in figure 2. The long hollow staff or tube houses a square operating rod and carries a head at its forward end. The head partially houses a wedge connected to the operating rod and has transverse slots for the measuring point carriers. The carriers are supported on the wedge by T-shaped slots which engage with the T-shaped flutes of the wedge. The operating lever or handle is mounted at the rear end of the staff. The handle is trunnioned to a slide which is attached to the square operating rod by an interior adjusting connection nut. The handle and slide have a sliding motion on the end of the tube and the movement of the handle is communicated through the operating rod to the wedge.

b. Movement of the wedge backward or forward causes a corresponding movement of the measuring points in or out. The slide to which the handle is trunnioned carries a vernier scale calibrated relative to the known taper of the wedge. The scale is graduated to indicate variations in the diameter of the cannon bore being measured from the normal diameter or caliber of the cannon.

4. SHIPMENT.

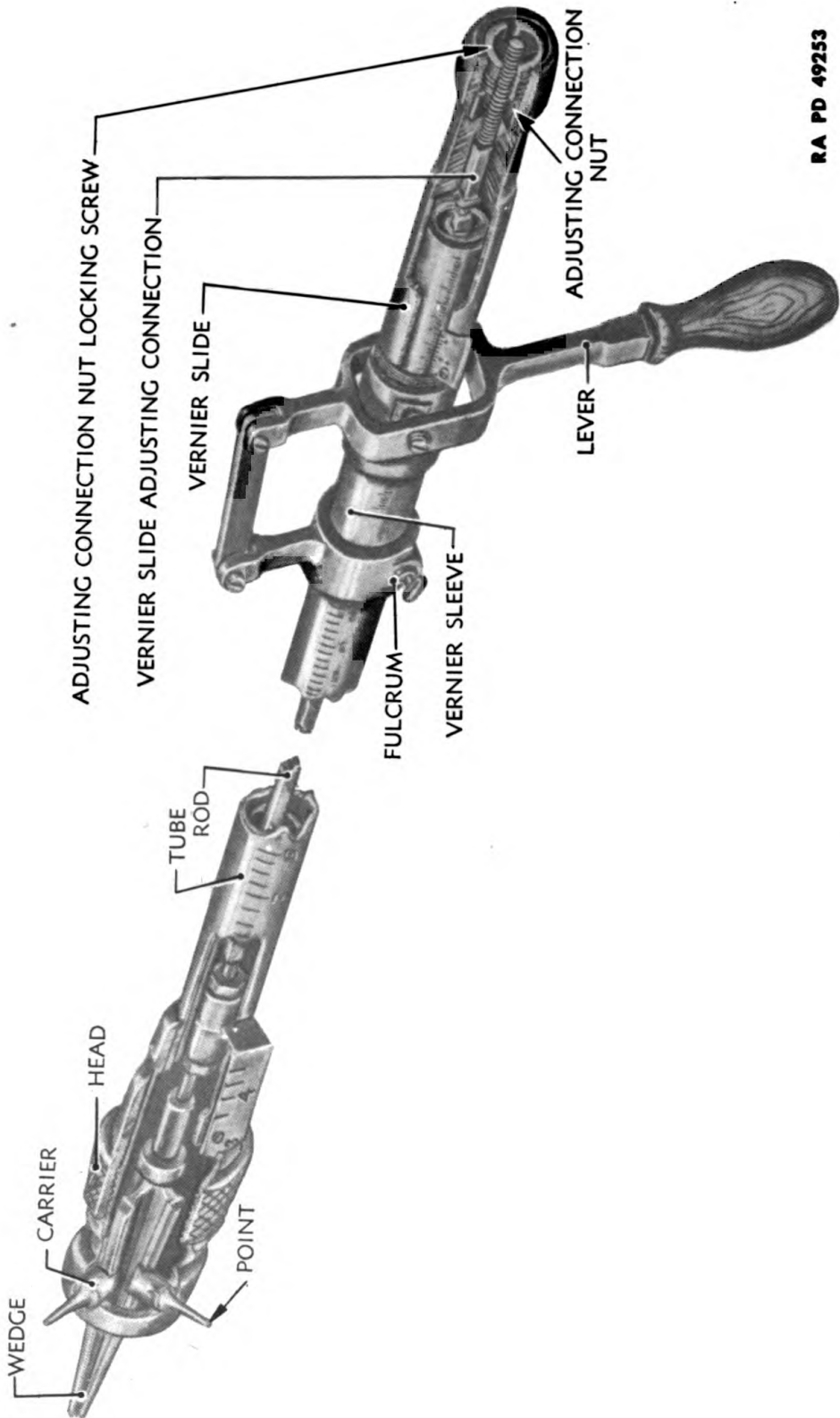
a. Star gages are packed in chests according to the cannon to be measured (fig. 3). On initial requisition, the head tube with head and carriers assembled thereon, the required number of extension staff assemblies, the handle assembly, an extra head and various necessary accessories, including measuring points, will be shipped in a chest. The measuring points for the 0.75-inch gage are always installed in the head

¹The 0.75-inch star gage is used only at proving grounds and factories.

²The larger diameters are measured by using distance pieces between the measuring point carriers and the measuring points.

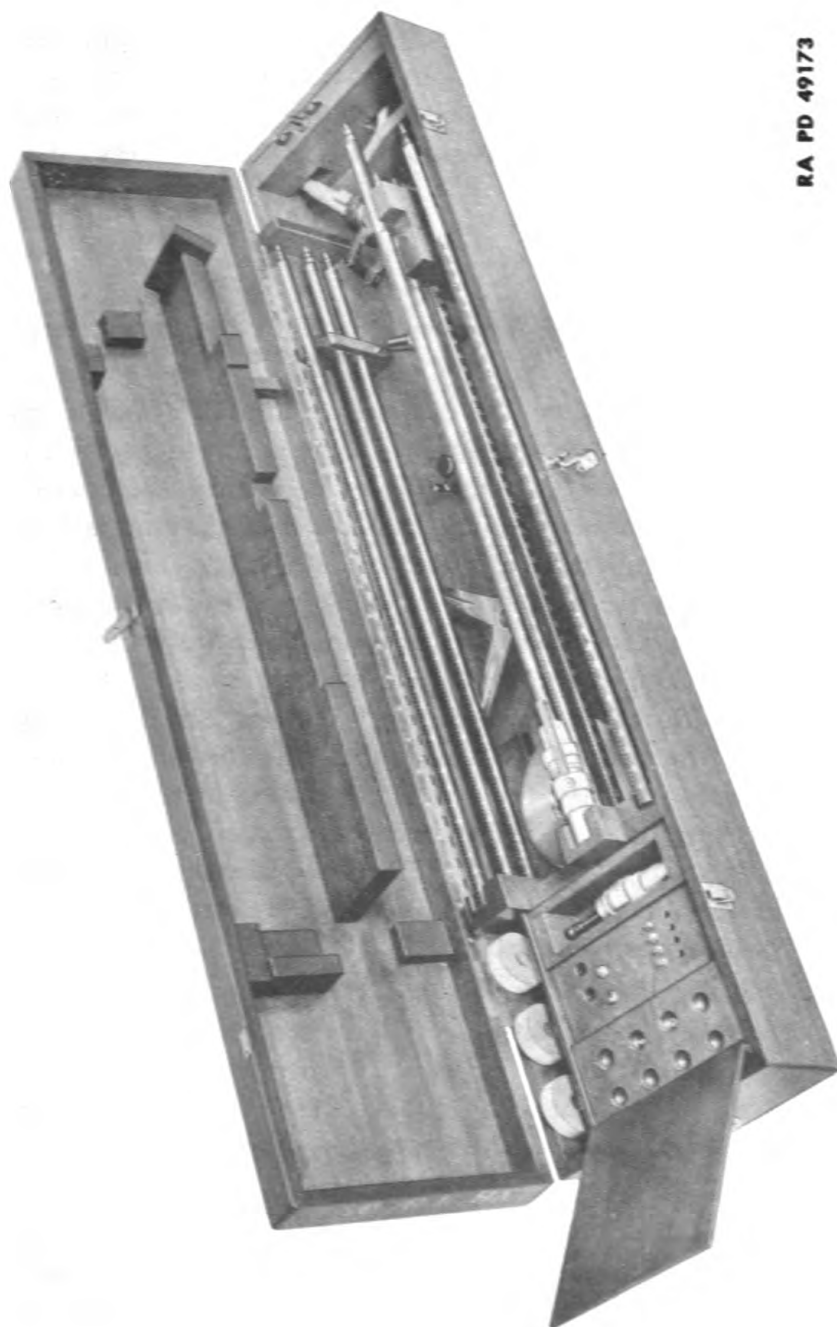
³When provided with a special 3-inch minimum diameter head, the 5.75-inch star gage may be used for cannon of 6-inch and 155-mm caliber.

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Figure 2—Schematic View of Lever-type Star Gage

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Figure 3—2-inch Star Gage and Accessories in Chest

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when the gage is shipped. The measuring points for the 1.35-inch and 2-inch gages may be installed in the head or may be shipped separately in the gage chest. The measuring points for the 5.75-inch gage are always shipped separately in the gage chest. Size, model and serial number of the cannon to be measured should be stated. If more than one model of cannon is to be gaged or if two cannon of the same model but with a different number of grooves are to be gaged, additional measuring points, spacing washers, size rings, rifling guides and other accessories will be supplied (compare Table I).

5. DESCRIPTION OF GROUPS.

a. **Head Tubes** (fig. 4). The head tubes of the various star gages are essentially similar.

(1) The head tube is a piece of steel tubing with a scale engraved on its exterior surface. The scale graduations are in inches and fourths, the inches being numbered. Two types of head tube are provided, one with graduations to 36 inches and the other with graduations to 50 inches. A knurled head tube coupling or, in the 0.75-inch gage, a lock nut, with an interior thread to receive the gage head, is mounted at the forward end of the tube. The head coupling can rotate about the head tube or can be locked to the head tube by tightening a set screw or, in the case of the 5.75-inch gage, engaging a locking pin. A bushing forms an extension to the rear of the head tube. The forward portion of the bushing is installed tightly (tinned and sweated in place) in the rear portion of the head tube. The exposed rear portion of the bushing has a threaded plug securely mounted (tinned and sweated) on it. This plug fits into a sleeve-joint nut installed tightly in the interior of the forward portion of the first extension tube.

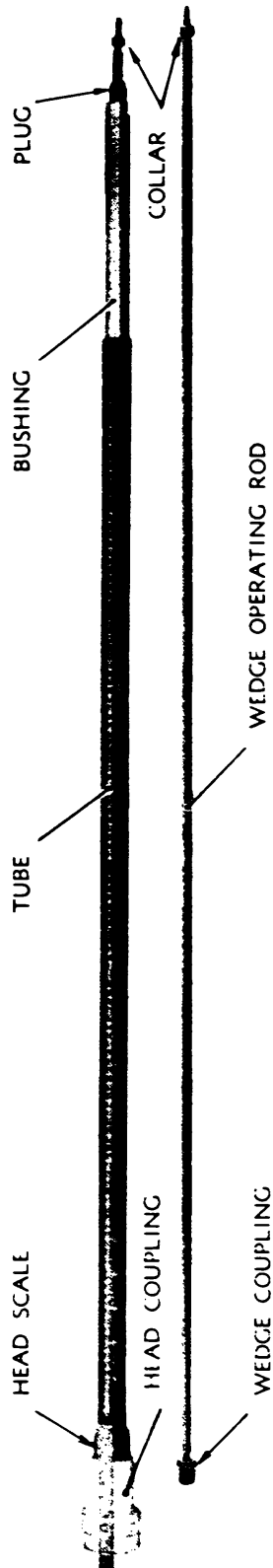
(2) The head tubes are provided with square-holed bearings or supports for the wedge operating rod. The head tubes of the 0.75-inch, the 1.35-inch and the 2-inch gages have one support which is tinned and sweated in place. The head tube of the 5.75-inch gage has two supports which are screwed to the tube to prevent them from rotating when the operating rod is removed.

(3) The operating rod is threaded at both ends. At its forward end, the wedge operating rod is provided with a coupling for joining it to the wedge. At its rear end, a pinned, threaded collar is installed to limit its motion. In the 0.75-inch, 1.35-inch and 2-inch gages, this rod is $\frac{1}{4}$ -inch square; in the 5.75-inch gage, it is $\frac{5}{16}$ -inch square.

b. **Head Assemblies** (fig. 5).

(1) **HEADS.** 3-point, 4-point, 6-point and combination star-gage heads are used. The 0.75-inch, 1.35-inch, 2-inch and 5.75-inch gages are

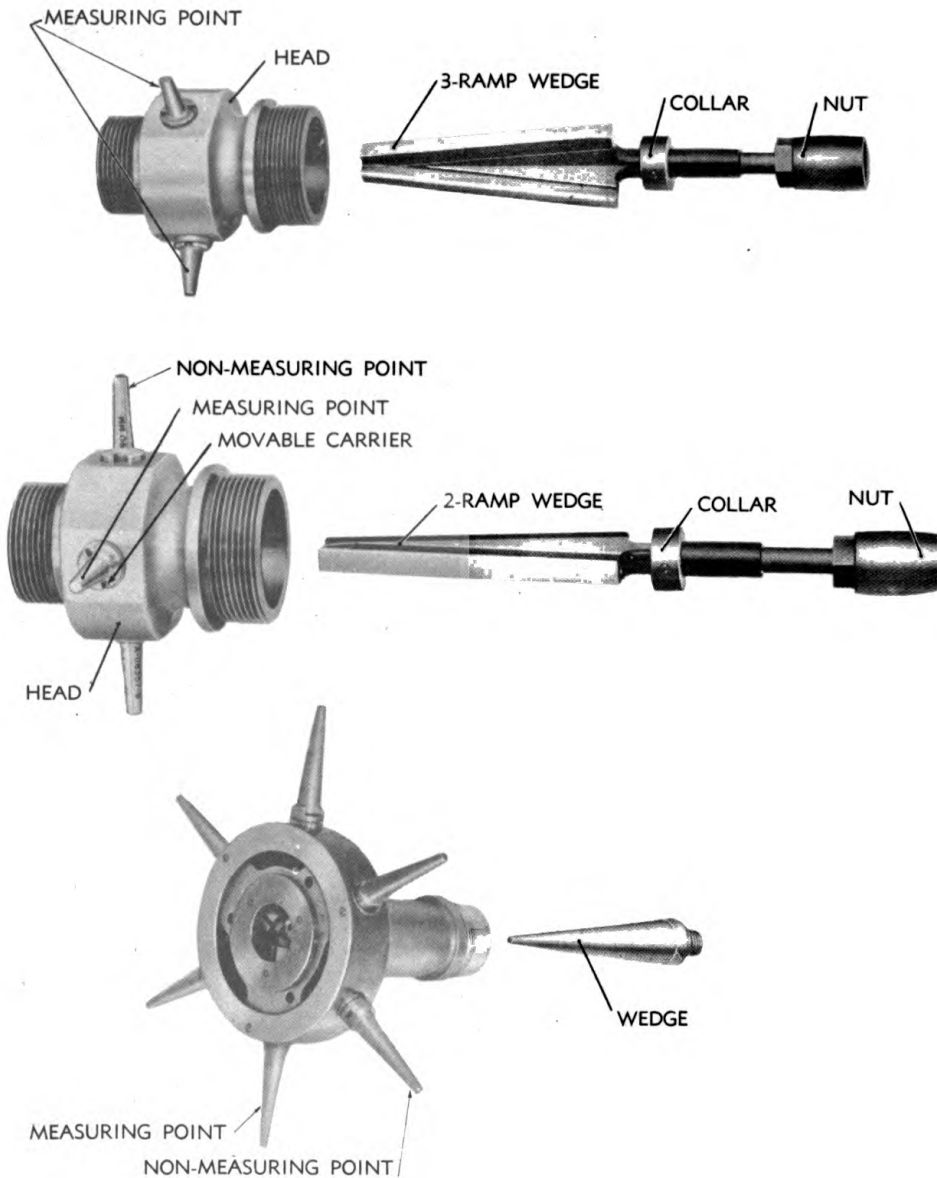
GENERAL DESCRIPTION AND FUNCTIONING



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Figure 4—Head Tube and Wedge Operating Rod of 2-inch Lever-type Star Gage

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Figure 5—3-point, 4-point and 6-point Star-gage Heads with Wedges

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usually provided with two head assemblies, one 3-point and one 4-point. In addition, the 5.75-inch gage is sometimes provided with a special 3-inch minimum diameter head (3-point or 4-point), a 6-point head, or a combination head. NOTE: The 4-point head of the 0.75-inch star gage is also called a 2-point head.

(a) In the 3-point head, the three points are installed in movable carriers (carriers which can move along the wedge). Thus, all three points are measuring points. In the 4-point head of the 0.75-inch, 1.35-inch and 2-inch gages, two measuring points are installed in movable carriers and two non-measuring points are installed in threaded holes in the head. The two non-measuring points are used as guides to keep the measuring points on the lands or in the grooves. In the 6-point head, three points are measuring points and three are non-measuring points. The three measuring points are installed in movable carriers and the three non-measuring points are installed in fixed carriers which do not move along the wedge.

(b) The combination star-gage head is rarely used. The combination head has two fixed carriers and three movable carriers. The two fixed carriers are mounted in the head at the 9 o'clock and 3 o'clock positions, respectively. One movable carrier is mounted in the head at the 12 o'clock position. Another movable carrier is mounted at the 8 o'clock position. The third movable carrier is mounted on a bearing which can be rotated through 60 degrees and locked at the 6 o'clock position or at the 4 o'clock position. The combination head can be used as a 3-point head by installing three measuring points at the 12 o'clock, 4 o'clock and 8 o'clock positions, respectively. It can be used as a 4-point head by installing points in the two fixed carriers (located at the 3 o'clock and 9 o'clock positions) and in the two movable carriers (located at the 12 o'clock and 6 o'clock positions).

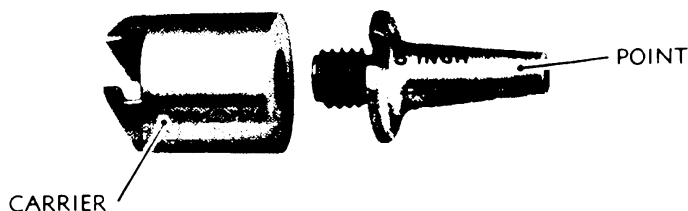
(2) **WEDGES** (fig. 5). The 3-point head wedge is divided longitudinally into three T-shaped flutes or ramps on which the measuring point carriers ride. The stem or shank of the wedge is provided with a pinned, threaded collar which acts as a stop to limit the motion of the wedge. The 4-point head wedge is similar to the 3-point head wedge, except that it has only two T-shaped flutes or ramps. A conical wedge is used in all of the 5.75-inch gage head assemblies. The stem of this wedge has a collar to limit its motion and the "point" of the wedge is provided with a collar which serves as a guide for its motion.

(3) **MEASURING POINT CARRIERS** (fig. 6). Measuring point carriers are bored and tapped in their outer ends to receive the threaded ends of the measuring points. They ride snugly in the bushed or unbushed segments of the gage head. The carriers used with the 0.75-inch, the 1.35-inch and the 2-inch gages are designed with a tapered T-slot lower

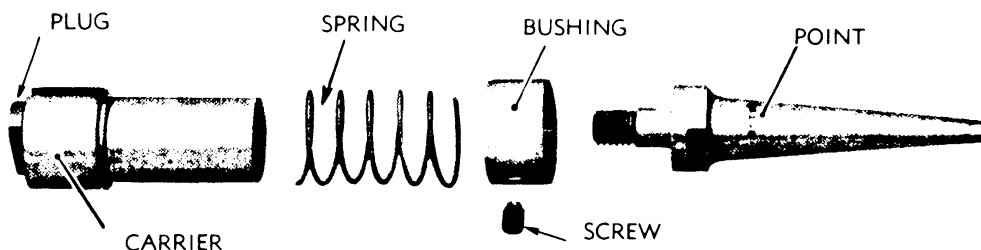
ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES



CARRIER AND SOLID MEASURING POINT FOR 20-MM GUN (0.75-INCH GAGE)



CARRIER AND SOLID MEASURING POINT FOR 3-INCH GUN (2-INCH GAGE)



CARRIER AND SOLID MEASURING POINT FOR 240-MM HOWITZER CHAMBER
(5.75-INCH GAGE)

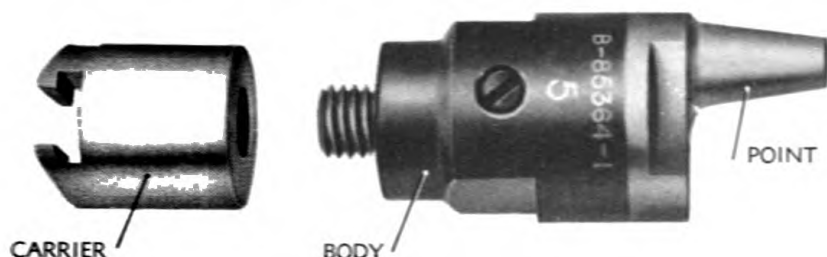
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Figure 6—Measuring Point Carriers and Solid Measuring Points

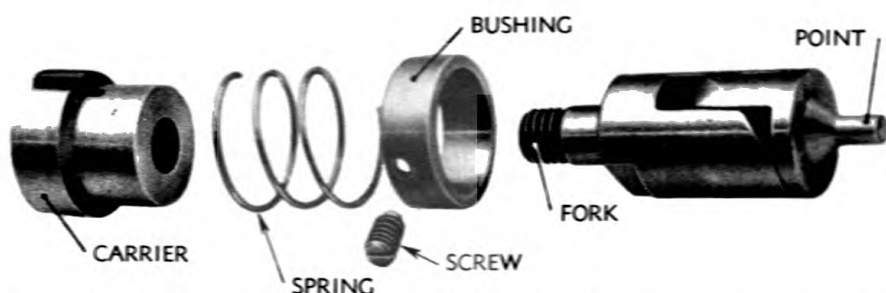
end to retain them on the wedge. The carriers used with the 5.75-inch gage are provided with springs and tapered plugs to retain them on the cone.

(4) MEASURING POINTS (fig. 6A). Measuring points are provided in sets and are of three types—solid, offset and breakdown. Only the solid-type or, in some cases, the solid-type and the offset-type are issued to ordnance field personnel. Offset points are needed when a 3-point head is used to gage a rifled bore having an even number of lands and grooves not divisible by three. For example, to star-gage the 4.5-inch Gun M1, which has 32 lands and grooves, a 2-inch gage is used with a 4-point head and four solid points or a 3-point head and one solid point and two offset point assemblies. The offset point assemblies are so constructed that they can be moved slightly to make them ride squarely

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CARRIER AND OFFSET POINT FOR 4.5-INCH GUN (2-INCH GAGE)



CARRIER AND BREAKDOWN POINT FOR 8-INCH GUN, MK. VI, (5.75-INCH GAGE)

RA PD 45111

Figure 6A—Measuring Point Carriers and Offset and Breakdown Measuring Points

in the center of the lands or grooves. In breakdown point assemblies, the points are hinged to point bodies to permit the point to drop so as to be perpendicular to the point body and carrier. This type of point is used when measuring bottleneck chambers such as that of the 240-mm howitzer.

c. **Extension Staff Assemblies** (fig. 7). Each extension staff assembly includes an extension tube and an extension operating rod.

(1) The extension tube is made of steel tubing and has a scale engraved on the exterior surface. The extension tubes, like the head tubes, contain square-holed supports which are tinned and sweated in place or, in the case of the 5.75-inch gage, held in place by a screw. Each tube has a sleeve-joint nut tightly installed in the interior near its front end and a bushing tightly installed at the rear end. As in the head tube, the bushing forms an extension to the extension tube and has a threaded plug securely mounted on its exposed end. Extension tubes are secured together by screwing the threaded plug at the rear end of one tube bushing into the sleeve-joint nut at the forward end of the next tube.

(2) Each extension staff assembly houses an extension operating rod which rides in the supports in the tube. Extension operating rods

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Figure 7—Extension Staff Assembly and Extension Operating Rod of 2-inch Lever-type Star Gage

GENERAL DESCRIPTION AND FUNCTIONING

are threaded at both ends and have a pinned coupling at the front end and a pinned collar at the rear end. Two extension rods are secured together by screwing the threaded rear end of one into the coupling at the front end of the other. The collar pinned to the rear end of each extension operating rod limits the extent of coupling.

(3) The available extension staff assemblies are noted in the following subparagraphs. As stated previously (par. 4), only those extension staff assemblies needed for the cannon to be gaged are supplied on initial requisition.

(a) The 0.75-inch star gage is provided with two extension staff assemblies, one graduated from 35 to 70 inches and the other from 71 to 106 inches.

(b) The 1.35-inch gage is provided with four 36-inch extension staff assemblies, graduated from 37 to 72 inches, 73 to 108 inches, 109 to 144 inches, and 145 to 180 inches, respectively.

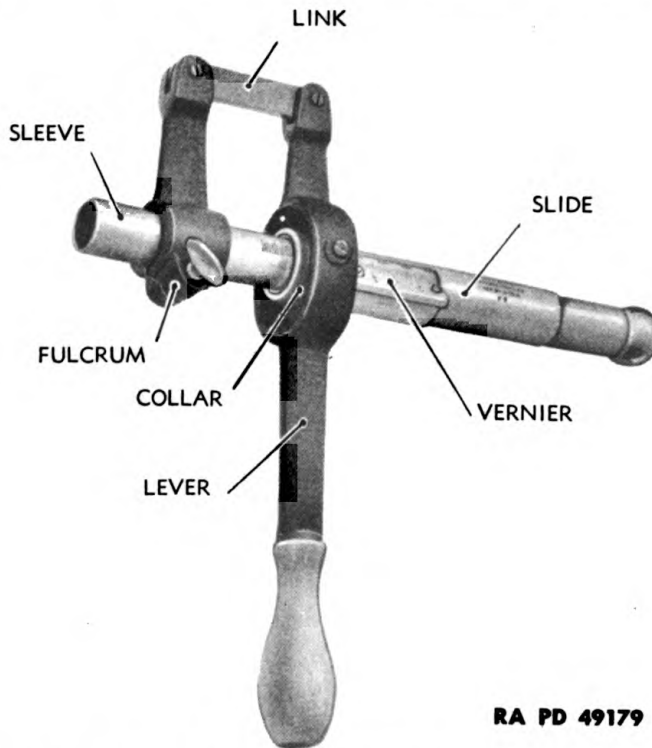
(c) The 2-inch gage is provided with one set of eight 36-inch extension staff assemblies, one set of six 36-inch extension staff assemblies, and one set of three 50-inch extension staff assemblies. The set of eight 36-inch staff assemblies is used with the 36-inch head tube and permits a total length of bore measurement of 324 inches. The set of six 36-inch staff assemblies is used with the 50-inch head tube and permits a total length of bore measurement of 266 inches. The set of three 50-inch staff assemblies is also used with the 50-inch head tube and permits a total length of bore measurement of 200 inches.

(d) The 5.75-inch gage is provided with fifteen 50-inch extension staff assemblies which, added to the 59-inch head tube, make possible a total length of bore measurement of 809 inches.

d. Slide Group (fig. 8).

(1) In the lever-type of star gage, a graduated vernier sleeve forms an extension to the last extension tube. The coupling between sleeve and tube is similar to the coupling between two tubes—that is, the threaded plug at the exposed end of the tube bushing mates with a sleeve-joint nut which is tightly installed in the interior of the vernier sleeve.

(2) A vernier slide slides over the sleeve, and the graduations on the sleeve are visible through an aperture in the slide alining with a flat vernier held on the vernier slide by two screws. Rotation between the sleeve and the slide is prevented by a key which is secured to the sleeve by a screw and which translates in a slot or keyway in the slide. The vernier slide is secured to the operating rod by a threaded vernier slide adjusting connection. This connection is mounted in the interior

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Figure 8—Handle, with Slide, Assembly (2-inch Star Gage)

portion of the vernier slide and the threaded rear end of the operating rod screws into it.

(3) Movement of the vernier slide and the operating rod connected to it is produced by an operating lever. The lever is trunnioned to the slide collar and is connected by a link to a fulcrum clamped near the forward end of the sleeve.

Section III

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

	Paragraph
General	6
2-inch star gage	7
1.35-inch star gage	8
0.75-inch star gage	9
5.75-inch star gage	10

6. GENERAL.

a. Star-gage units are shipped in assembled units which need not be disassembled to assemble the gage for operation. The gage is prepared for use by assembling the assembled units or subassemblies stored in the gage chest. If the assembled gage does not function smoothly, or if the gage is to be prepared for storage, the subassemblies may be disassembled by the procedure described below.

CAUTION: Star gages are costly precision instruments and should be handled as such.

7. 2-INCH STAR GAGE.

a. **Head Tube with 3-point Head and Wedge Operating Rod.** The head tube is received with head, size-ring spider cap, carriers, wedge and wedge operating rod installed. The measuring points may be installed in the head or may be stored separately in the chest. It will be assumed here that the measuring points are in place in the head. Ordinarily, this unit will be disassembled only when the head is replaced, as when changing from a 3-point head to a 4-point head, or when the gage is to be stored for an indefinite period.

b. Disassembly.

- (1) Unscrew and back off size-ring spider cap A116321 (fig. 9).
- (2) Loosen the head coupling set screw A116331 with a small screwdriver. (Screw A116331 is diametrically opposite scale A116334 and is not shown in fig. 10.)
- (3) Using a suitable screwdriver, unscrew and remove head scale screws A116335 and A116336 and remove head scale A116334 (fig. 10).
- (4) Unscrew coupling A116330 from head A116322 and back off coupling from head tube.
- (5) Mount the rear end of the operating rod on a wooden block having a suitable hole and drive out the taper pin from operating rod collar A116276 with a suitable center punch. Remove the collar (fig. 11).

CAUTION: Before removing the collar, scratch a mark on the collar and on the wedge operating rod C37179B so that the collar may be replaced exactly as removed.

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Figure 9—Head Tube with Cap Installed (2-inch Star Gage)

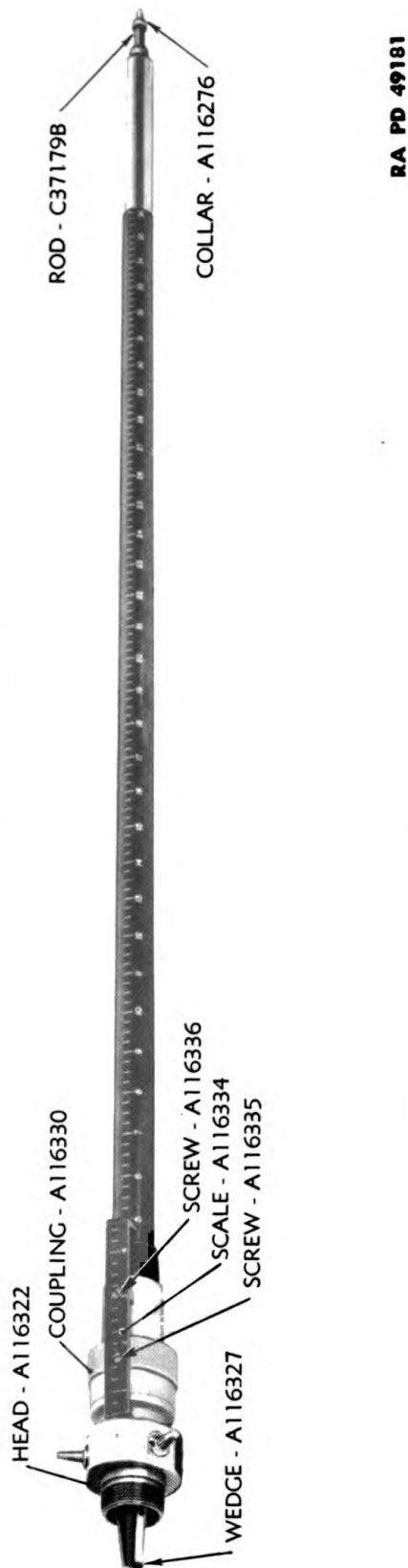
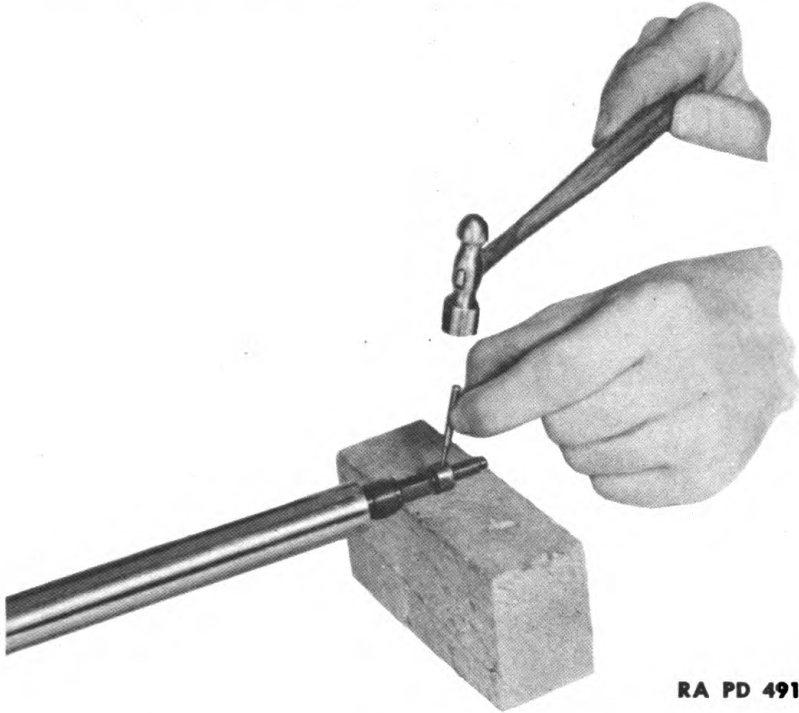


Figure 10—Head Tube with Cap Removed (2-inch Star Gage)

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

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Figure 11—Driving out Taper Pin from Operating Rod Collar (2-inch Star Gage)

(6) Remove head, wedge and wedge operating rod as a unit from the head tube (fig. 12).

(7) Uncouple head, with wedge, assembly from wedge operating rod, using the two end wrenches A116304 (fig. 13).

(8) Unscrew and remove measuring points from head, using the special teat wrench provided (fig. 51).

(9) Remove head with measuring point carriers from wedge.

(10) Remove measuring point carriers from head.

NOTE: The wedge assembly will not be disassembled.

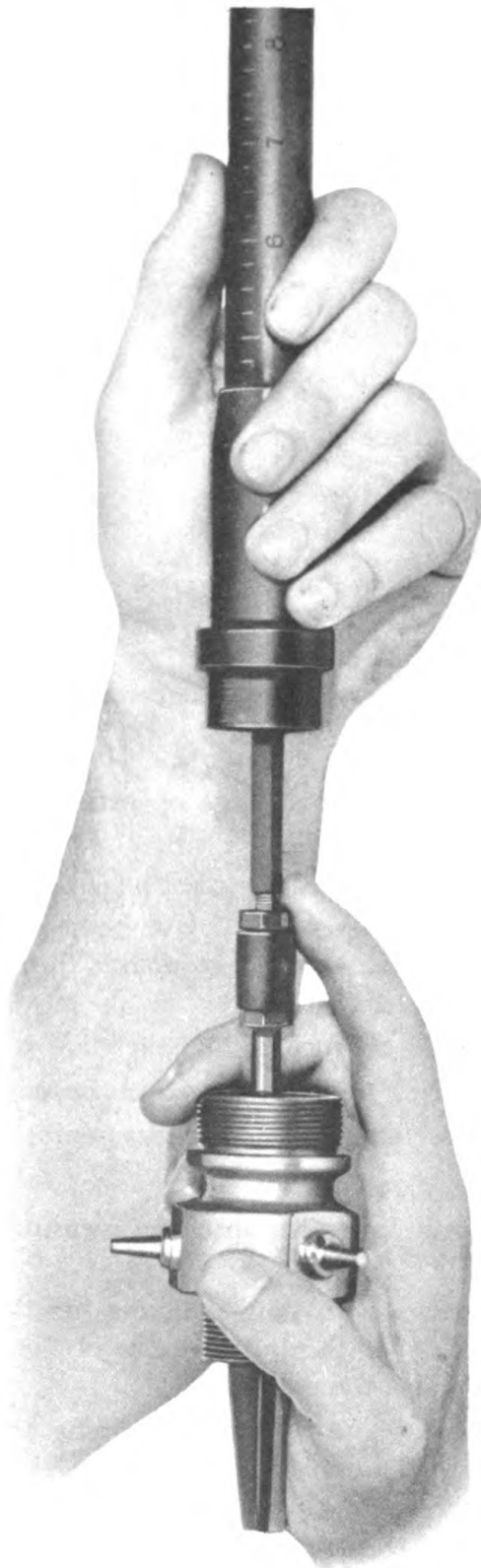
c. Assembly.

(1) Screw the measuring points into the measuring point carriers loosely.

(2) Install the carriers, with points, in the head with the tapered ends of the carrier T-slots at the *forward* side of the head so that the carriers will ride squarely on the wedge.

(3) Assemble the head and wedge by guiding the T-slots of the carriers onto the T-shaped ramps of the wedge. Use one hand to hold the wedge stem and the other to guide the head (fig. 14). Guide the T-slot of one carrier approximately over one of the T-shaped ramps of the wedge; then swivel the head slightly so that all three carriers

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Figure 12—Removing Head, Wedge and Operating Rod as a Unit (2-inch Star Gage)

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

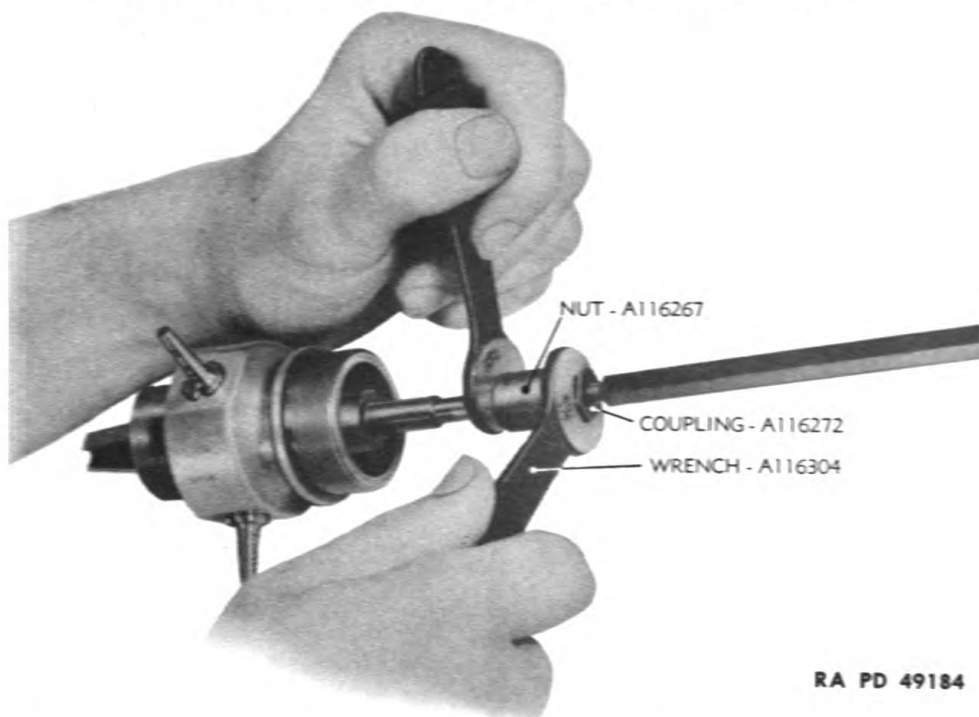


Figure 13—Uncoupling Head, with Wedge, Assembly from Wedge Operating Rod (2-inch Star Gage)



Figure 14—Assembling Head with Carriers and Points on Wedge Operating Rod (2-inch Star Gage)

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Figure 15—Exploded View of Extension Staff Assembly (2-inch Star Gage)

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

engage. Check whether the carriers are engaged by moving the wedge back and forth and noting the movement of the measuring points inwardly and outwardly.

(4) Tighten the measuring points in the carriers with the special teat wrench.

(5) Reverse steps (7) through (1) of the disassembly procedure in step b above.

d. Head Tube with 4-point Head and Wedge Operating Rod.

(1) To disassemble a head tube with a 4-point head, follow the disassembly procedure given in step b above. Note that this head has only two carriers.

(2) To assemble a head tube with 4-point head, follow the assembly procedure given in step c above, taking care to guide the T-slots of the two movable carriers onto the two T-shaped ramps of the wedge (fig. 5).

e. To replace a 4-point head, with wedge, assembly, by a 3-point head, with wedge, assembly, or vice versa, proceed as follows:

(1) Perform the steps described in b (1) through (8).

(2) Assemble the new head, with wedge, assembly on the wedge operating rod, using the end wrenches A116304.

(3) Reverse the steps described in b (8) through (1).

f. **Extension Staff Assembly** (fig. 15). All the extension staves are similar except for the scale markings. Ordinarily, the assembly will be disassembled only when the gage is to be stored for an indefinite period.

(1) Mount the rear end of the operating rod on a wooden block and drive out the taper pin from the operating rod collar A116276 with a suitable center punch. Scratch marks on the collar and on the rod so that it may be installed exactly as removed. Remove the collar.

(a) Withdraw extension operating rod C37181J from tube C37181A.

(2) To assemble, reverse the procedure described in step (1) above.

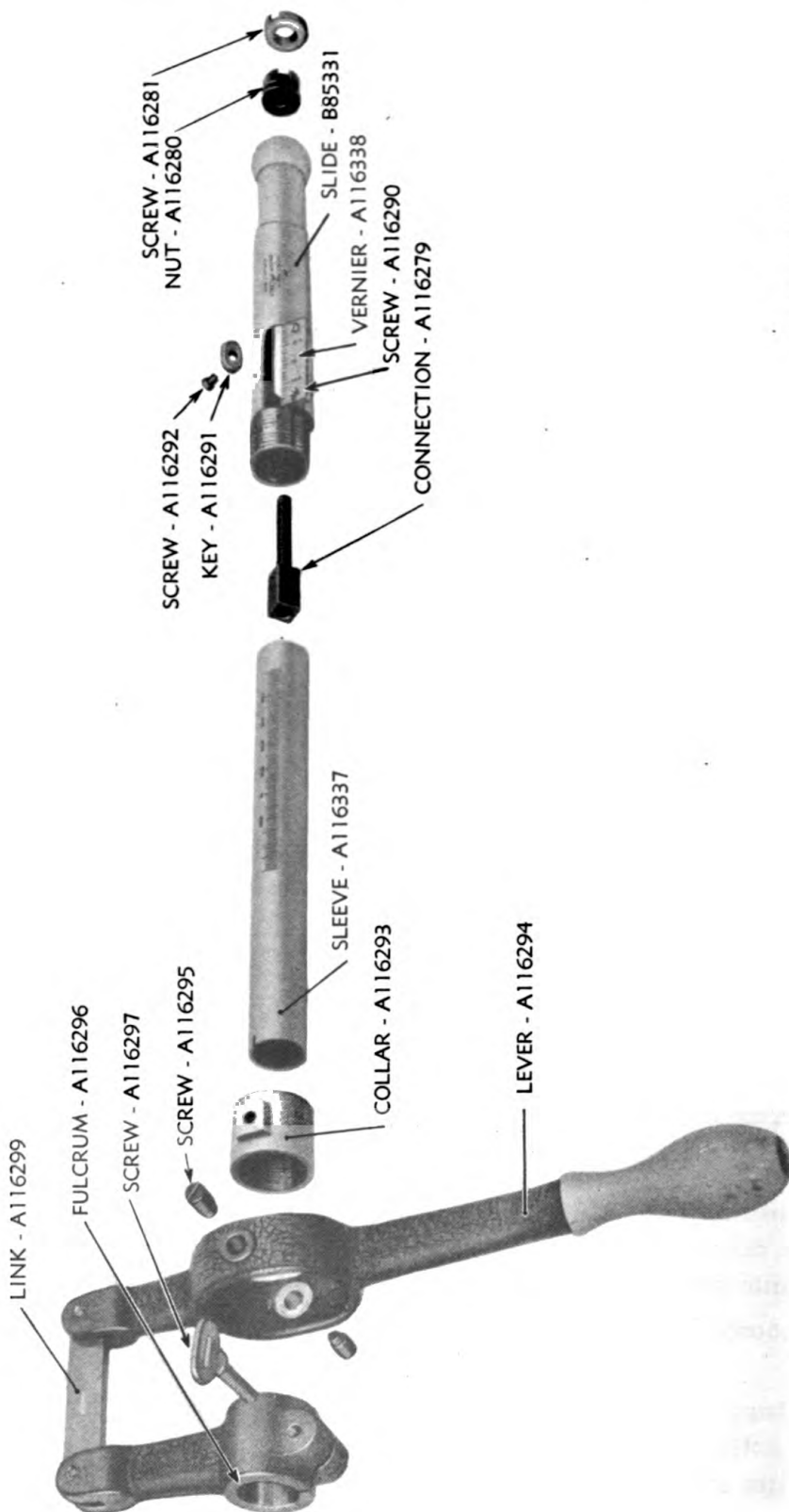
g. **Handle, with Slide, Assembly** (fig. 16). If the handle, with slide, assembly does not function properly, or if the gage is to be stored for an indefinite period, the assembly may be disassembled as follows:

(1) Loosen screw A116297 which clamps fulcrum A116296 to the sleeve.

(2) Using a suitable screwdriver, unscrew and remove the two trunnion collar screws A116295 (figs. 16 and 17) and remove lever, link and fulcrum as a unit.

(3) Unscrew and remove trunnion collar A116293.

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Figure 16—Exploded View of Handle, with Slide, Assembly (2-inch Star Gage)

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES



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Figure 17—Unscrewing Trunnion Collar Screw (2-inch Star Gage)

(4) Using special teat wrench (large end), unscrew and remove adjusting connection nut locking screw A116281 (figs. 16 and 18).

(5) Using special teat wrench (small end), unscrew and remove adjusting connection nut A116280.

(6) Unscrew vernier sleeve key screw A116292 with a small screwdriver and remove key A116291 (figs. 16 and 19).

CAUTION: Mark the key and slide so that the key will be installed exactly as removed.

(7) Withdraw vernier sleeve A116337 from vernier slide B85331.

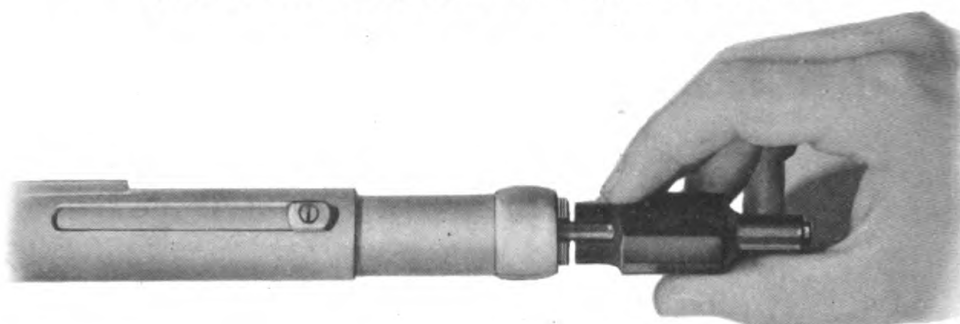
(8) Remove vernier slide adjusting connection A116279 through the forward end of the slide.

(9) Vernier A116338 can be removed from the slide after the two vernier screws A116290 are removed.

(10) To assemble the handle, with slide, assembly, reverse steps (9) to (1).

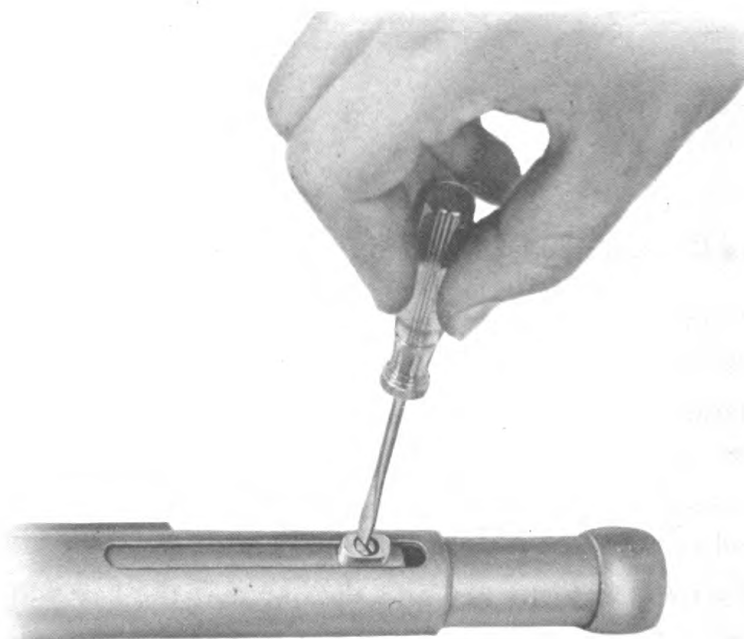
NOTE: If the vernier was removed, care must be taken when re-mounting the vernier to avoid scoring the sleeve. Hold the vernier slightly away from the sleeve with one hand while screwing the vernier screws with the other.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES



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Figure 18—Unscrewing Connection Nut Locking Screw with Special Test Wrench (2-inch Star Gage)



RA PD 49190

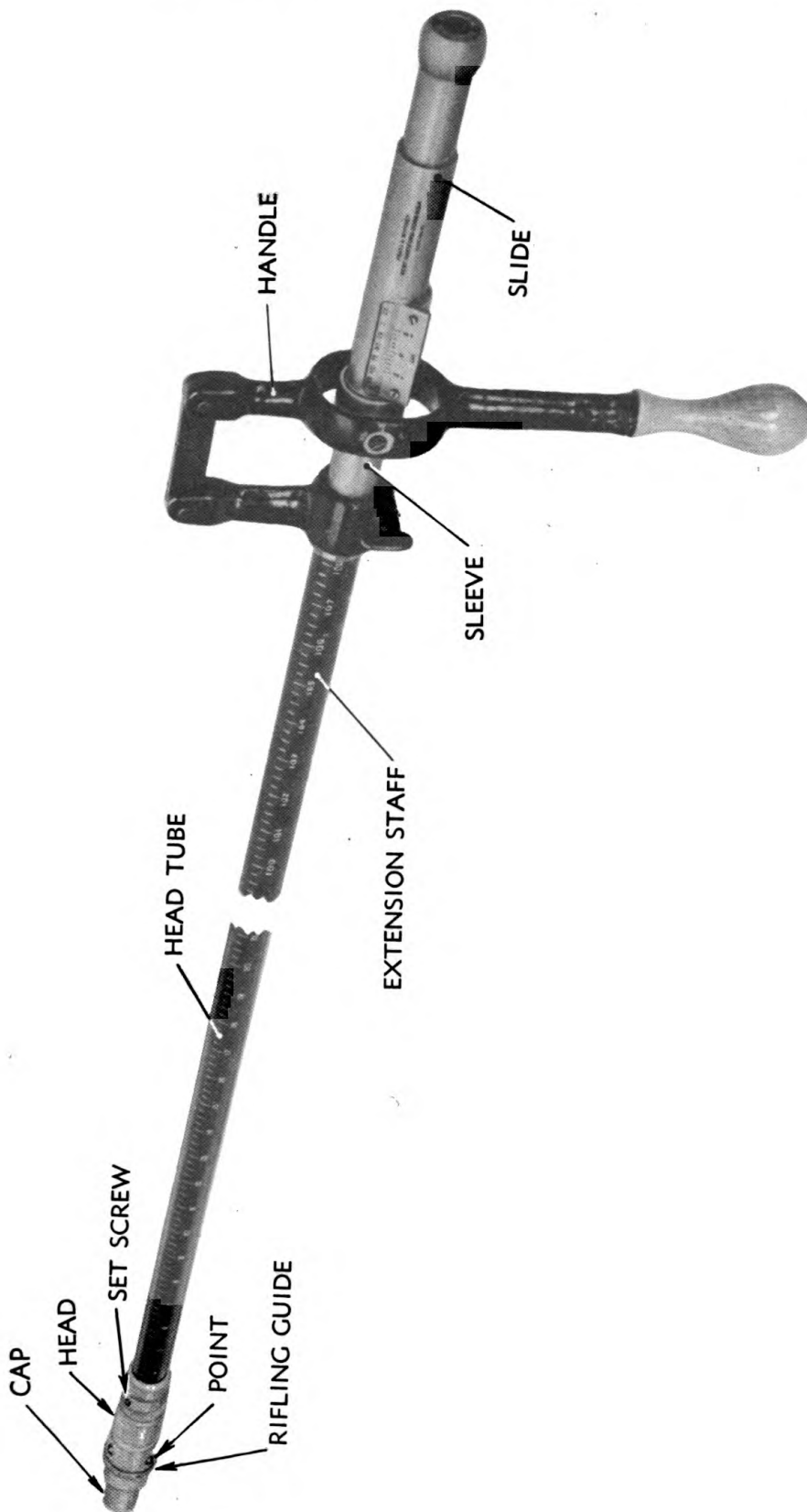
Figure 19—Unscrewing Vernier Sleeve Key Screw (2-inch Star Gage)

8. 1.35-INCH STAR GAGE.

a. The 1.35-inch star gage differs from the 2-inch star gage in the size of the star-gage head, the absence of a head scale and the provision of two sleeves and verniers, one graduated in English units, the other in metric units (fig. 20). The metric vernier sleeve and vernier are rarely used.

b. The disassembly and assembly of the head tube with head (3-point or 4-point), wedge and wedge operating rod are the same as for

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Figure 20—Exterior View of 1.35-inch Star Gage with 3-point Head Assembled for Star-gaging

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES**

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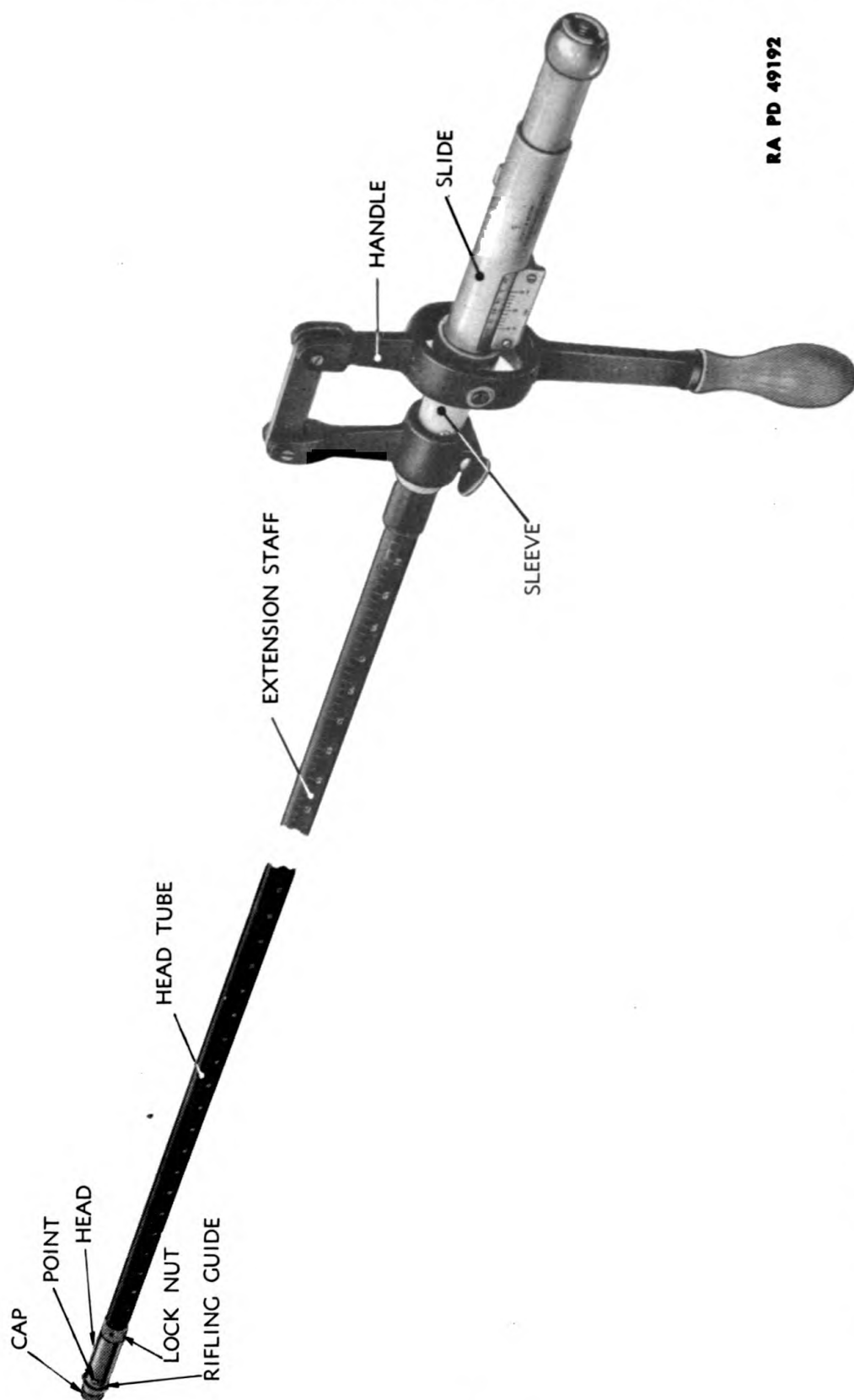


Figure 21—Exterior View of 0.75-inch Star Gage with 3-point Head Assembled for Star-gaging

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

the 2-inch star gage except that there is no head scale to remove or install. The disassembly and assembly of the extension staves and the handle, with slide, assembly are precisely the same as for the 2-inch star gage (par. 7 f and g).

9. 0.75-INCH STAR GAGE.

a. Head Tube with 3-point Head and Wedge Operating Rod (figs. 21, 22 and 23). The wedge is designed with a "button" at its rear end which fits into a slot in the forward end of a wedge stem (fig. 23). The other end of the wedge stem is coupled to the wedge operating rod. The wedge operating rod of the 0.75-inch star gage is much longer, relative to the head tube, than that of the 2-inch or 1.35-inch star gages. As in the 1.35-inch star gage, no head scale is provided. A knurled lock nut is provided instead of the knurled head coupling of the 2-inch gage.

b. Disassembly.

(1) Unscrew and remove size-ring spider cap A116551 from gage head A116571.

(2) Mount the rear end of the operating rod on a wooden block and drive out the taper pin from operating rod collar A116276 with a suitable center punch. Remove the collar.

CAUTION: Before removing the collar, scratch a mark on the collar and on the wedge operating rod C37212D so that the collar may be replaced exactly as removed.

(3) Using a suitable screwdriver, unscrew and remove the flathead machine screws BCLX3FC from the forward end of the head tube (fig. 22).

(4) Remove the head, wedge and wedge operating rod as a unit from the head tube.

(5) Using a suitable screwdriver, unscrew and remove set screw BCUX1EB in the knurled lock nut A116553.

(6) Unscrew and back off lock nut A116553.

(7) Unscrew and remove the measuring points from the head with the special teat wrench provided (fig. 51).

(8) Back off head A116571 from the wedge.

(9) Remove the measuring point carriers from the head.

(10) Lift out wedge A116572 from the T-slot in wedge stem A116555 (fig. 23).

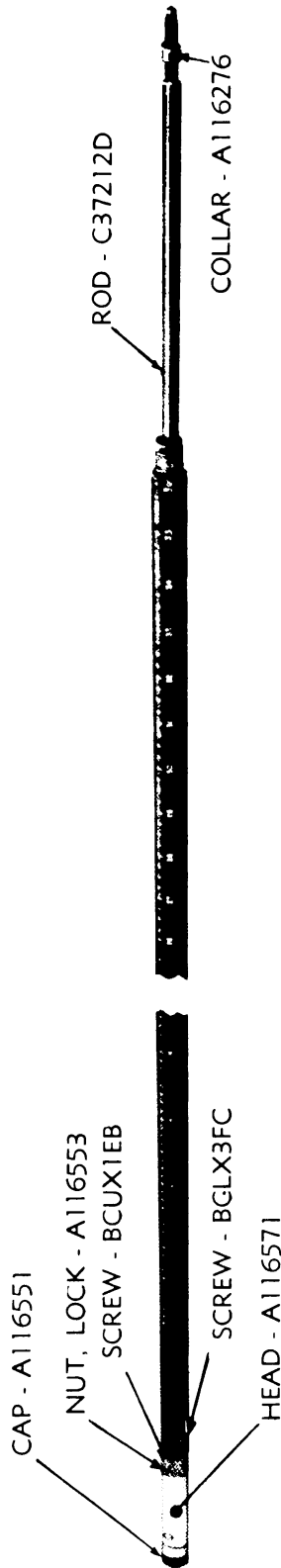
NOTE: The wedge operating rod assembly will not be disassembled.

c. Assembly.

(1) Install the wedge in the T-slot in the wedge stem.

(2) Screw the measuring points into the measuring point carriers loosely.

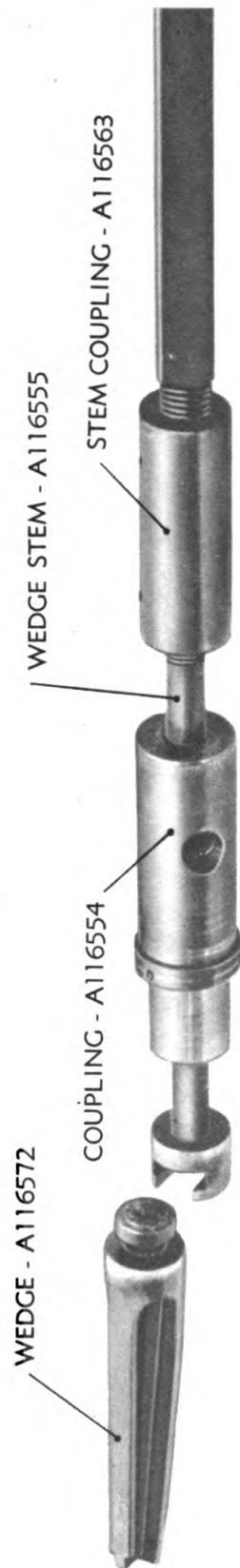
ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES



RA PD 49193

Figure 22—Head Tube and Wedge Operating Rod (0.75-inch Star Gage)

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES



RA PD 49194

Figure 23—3-ramp Wedge and Wedge Operating Rod (0.75-inch Star Gage)

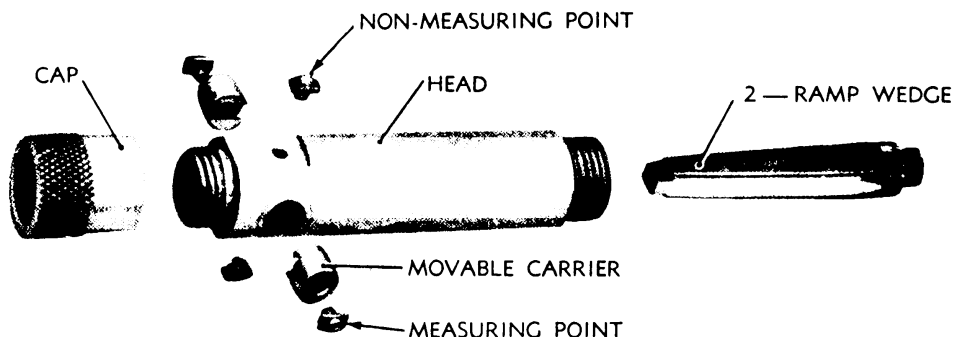
ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

(3) Install the carriers, with points, in the head, taking care that the tapered ends of the carrier T-slots are at the forward side of the head.

(4) Assemble the head and wedge, taking care to guide the T-slots of the three movable carriers onto the three T-shaped ramps of the wedge. Check whether the carriers are engaged by moving the head back and forth on the wedge and noting the inward and outward movement of the measuring points.

(5) Tighten the measuring points in the carriers with the special teat wrench.

(6) Reverse steps (6) through (1) of the disassembly procedure in step b.



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**Figure 24—4-point Head with Wedge and Cap for 0.75-inch Star Gage
(This Head Is also Called a 2-point Head)**

d. Head Tube with 4-point Head and Wedge Operating Rod.

(1) To disassemble a head tube with a 4-point head, follow the disassembly procedure given in b above. Note that this head has only two carriers (fig. 24).

(2) To assemble the head tube with 4-point head, follow the assembly procedure given in c above, taking care to guide the T-slots of the two movable carriers onto the two T-shaped ramps of the wedge.

e. To replace a 4-point head, with wedge, assembly with a 3-point head, with wedge, assembly, or vice versa, proceed as follows:

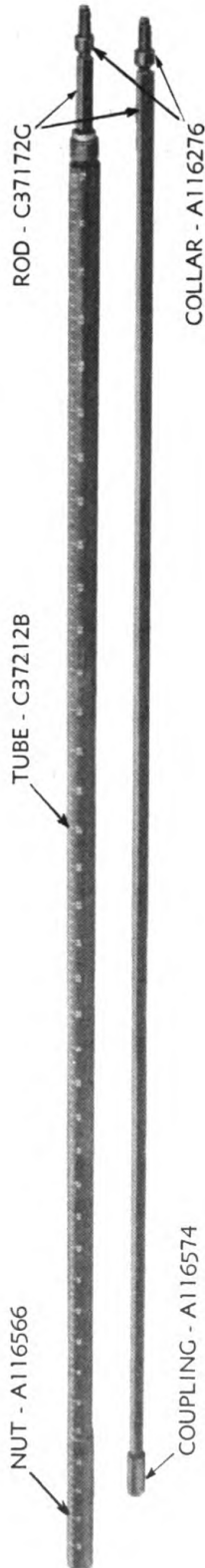
(1) Perform the steps described in paragraph 9 b (1) through (6).

(2) Back off the head from the wedge.

(3) Lift out the wedge from the slot in the wedge stem.

(4) Install the new wedge of the new head in the slot of the wedge stem.

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES



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Figure 25—Extension Staff Assembly and Extension Operating Rod of 0.75-inch Star Gage

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

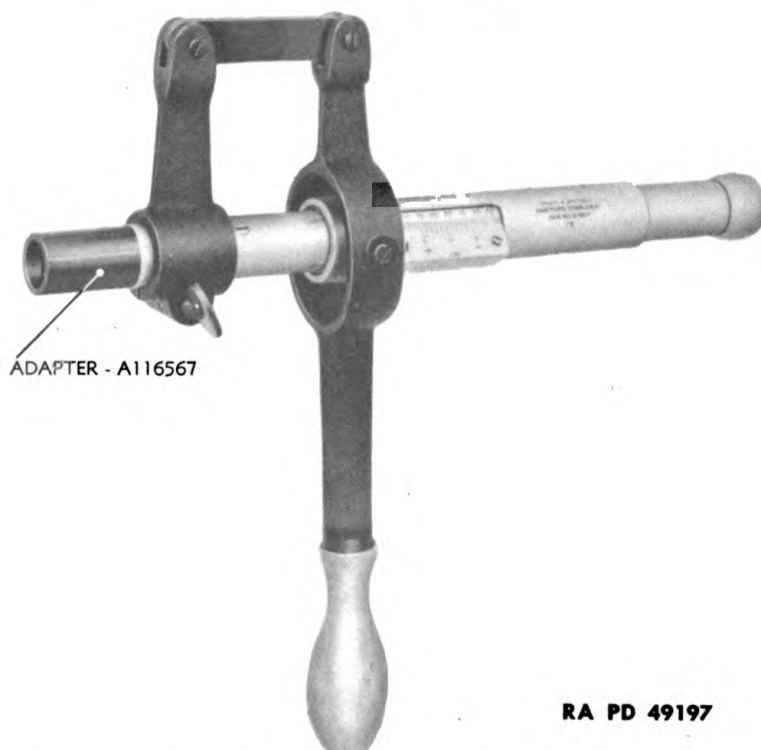
(5) Assemble the new head, with carriers and points, onto the wedge, taking care to guide the T-slots of the carriers onto the T-shaped ramps of the wedge.

(6) Reverse the steps given in paragraph 9 b (6) through (1).

f. Extension Staff Assembly (fig. 25).

(1) The extension staff assembly of the 0.75-inch star gage differs from that of the 2-inch and 1.35-inch star gages in the following details: The staff joint nut A116566 is sweated in place on the exterior of the tube, instead of the interior. The operating rod is longer, relative to the tube, than that of the 2-inch star gage.

(2) The assembly and disassembly of the extension staff assembly are the same as for the 2-inch gage (par. 7 f).



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Figure 26—Handle, with Slide, Assembly (0.75-inch Star Gage)

g. Handle, with Slide, Assembly (fig. 26).

(1) The handle, with slide, assembly of the 0.75-inch star gage differs from that of the 2-inch gage in the provision of an adapter to take up, in part, the excess length of the operating rod with respect to the head tube and extension tubes. The adapter will not be removed when the handle, with slide, assembly is disassembled.

(2) The assembly and disassembly of the handle, with slide, assembly are the same as for the 2-inch star gage (par. 7 g).

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES**10. 5.75-INCH STAR GAGE (fig. 27).**

a. Head Tube with 4-point Head and Wedge Operating Rod. The measuring points of the 5.75-inch gage are stored separately in the gage chest (par. 4). The 5.75-inch gage is provided with a conical wedge and the measuring point carriers are held against the wedge by springs and tapered plugs (compare par. 5 b). The size-ring spider cap of the other gages is here replaced with an outer wedge collar bearing on which the rifling guide is installed. No head scale is provided.

b. Disassembly (figs. 28 and 29).

(1) Pull locking pin knob A116396 sufficiently to release the $\frac{1}{16}$ -inch straight pin and give the knob a partial turn so that the straight pin is "locked" out of the locking pin sleeve A116393.

(2) Unscrew and back off head coupling A116392.

NOTE: If coupling A116392 and head B85348 are "bound," two operators will be necessary; one to hold the head and the other to unscrew the coupling. Wrenches should not be used.

(3) If it is necessary to replace the $\frac{1}{16}$ -inch straight pin, unscrew locking pin sleeve A116393 and remove the locking pin, with knob, assembly.

(4) Mount the rear end of the wedge operating rod C37191B on a wooden block having a suitable hole and drive out the taper pin from operating rod collar A116404 with a suitable center punch. Remove the collar (fig. 28).

CAUTION: Before removing the collar, scratch a mark on the collar and on the wedge operating rod so that the collar may be installed exactly as removed.

(5) Withdraw head, wedge and wedge operating rod as a unit from the head tube C37191A.

(6) Disconnect the head, with wedge, assembly from the wedge operating rod by using the two similar end wrenches provided (fig. 51).

(7) Remove movable carriers A116369 from wedge as follows (fig. 30):

(a) Install a measuring point in the movable carrier A116369 and screw it "home" with the $\frac{9}{16}$ -inch end wrench.

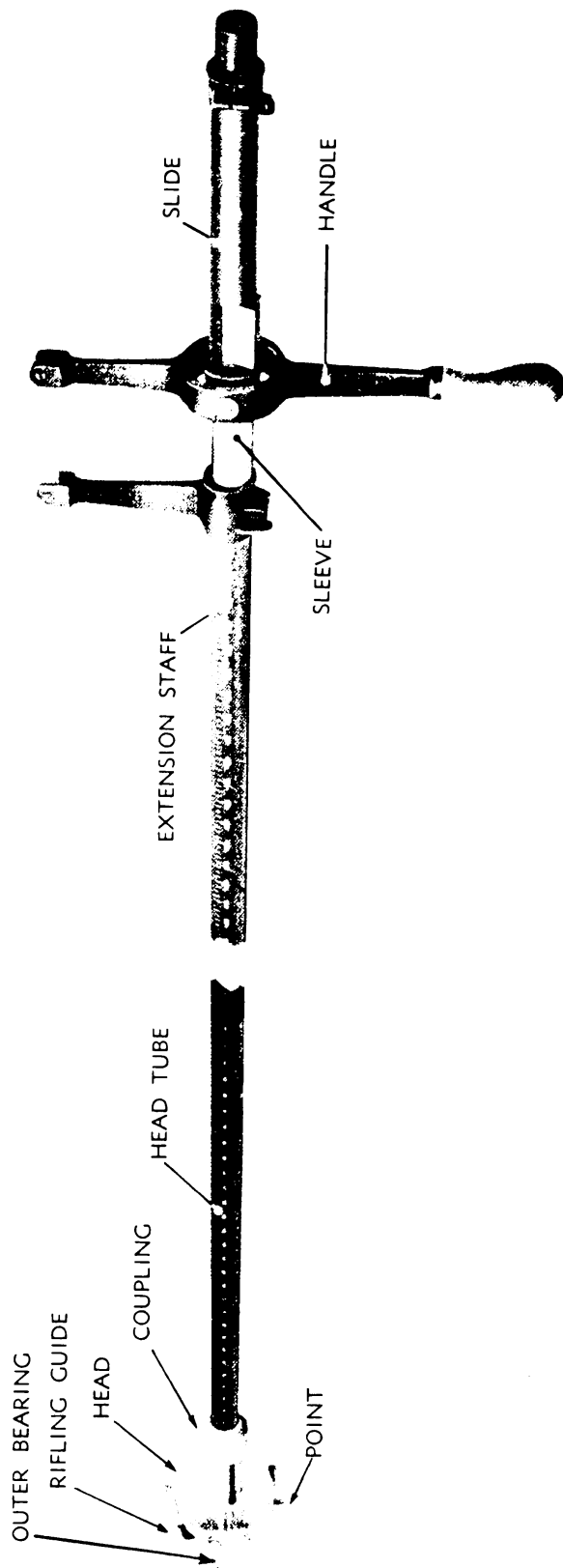
(b) Using a suitable screwdriver, unscrew and remove carrier bushing screw A116373.

(c) Remove point, carrier, plug, spring and bushing as a unit from the head.

(d) Unscrew and remove the measuring point.

(8) Back off head B85348 with outer wedge collar bearing B85349 from the wedge.

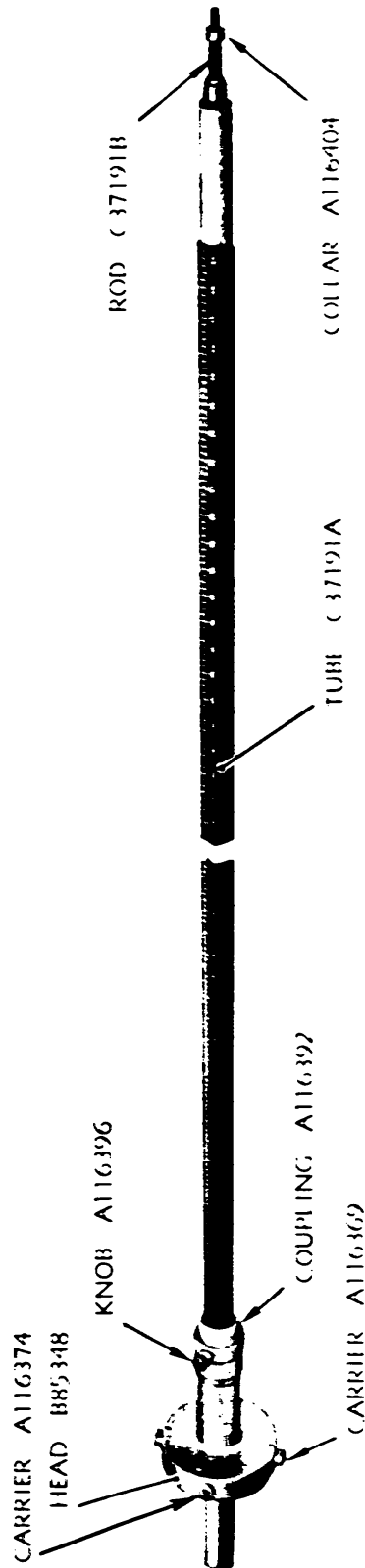
ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
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Figure 27—Exterior View of 5.75-inch Star Gage with 4-point Head Assembled for Star-gaging

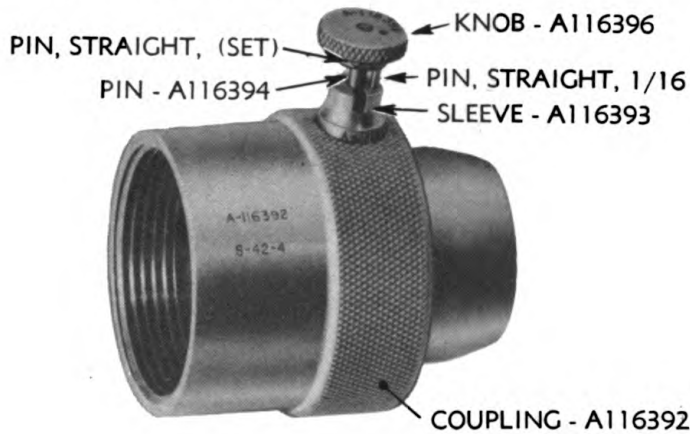
DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES



RA PD 49199

Figure 28—Head Tube with 4-point Head (5.75-inch Star Gage)

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IMPRESSION OUTFITS AND PRESSURE GAGES**



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Figure 29—Head Coupling with Locking Pin Knob (5.75-inch Star Gage)

(9) Using a suitable screwdriver, unscrew and remove screws A116367 which secure bearing B85349 to head B85348. Remove the bearing from the head.

CAUTION: Before removing the wedge collar bearing, mark the bearing and the head so that on assembly the holes in the bearing will line up with the matching holes in the head.

(10) Using a suitable screwdriver, unscrew and remove the wedge supporting collar set screw A116376. Back off the wedge supporting collar A116375 from wedge B85347.

c. **Assembly.** Reverse the steps given in b (10) through (1).

CAUTION: 1st—The movable carrier and carrier plug must be installed so that the tapered plug A116370 will ride squarely on the cone (fig. 30). 2nd—Care must be taken to engage the slot in the carrier with the projecting taper pin in the interior of the head and to aline the hole in carrier bushing A116372 with the corresponding hole in the head. 3rd—After the movable carrier is installed in the head, “lock” it in the extended position by giving the measuring point a partial turn.

d. **Head Tube with 3-point Head and Wedge Operating Rod.** Disassembly and assembly are the same as for the head tube with 4-point head and wedge operating rod (b and c above).

e. **Head Tube with 6-point Head and Wedge Operating Rod.** Disassembly and assembly are the same as for the head tube with 4-point head and wedge operating rod (b and c above).

f. **Head Tube with Combination Head and Wedge Operating Rod.**

(1) The combination head has five carriers, three of which are movable carriers (par. 5 b). One of the movable carriers is mounted

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

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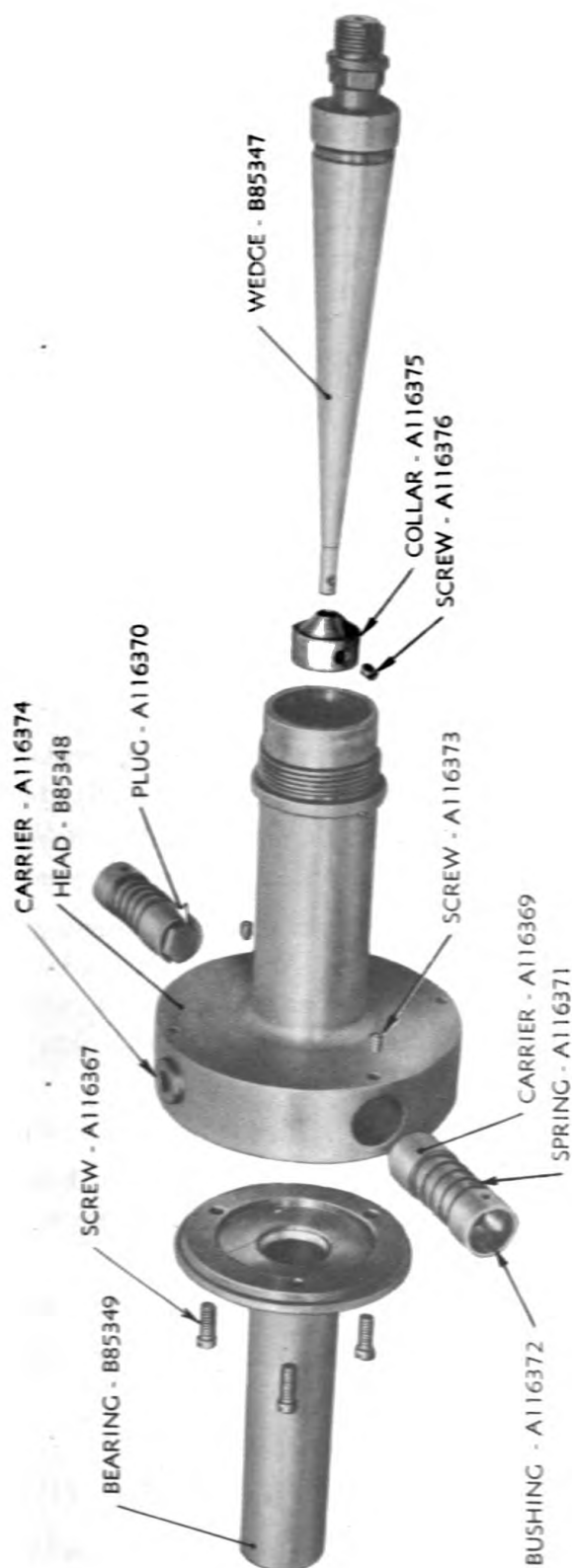


Figure 30—4-point Head, with Wedge, Assembly (5.75-inch Star Gage)

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

on a bearing which can be rotated through 60 degrees and locked at the 6 o'clock position or the 4 o'clock position. To disassemble, it will be necessary first to unscrew and remove a bearing clamping screw wing nut and bearing clamping screw.

(2) Except for the removal and installation of the bearing clamping screw wing nut and the bearing clamping screw, the disassembly and assembly of the head tube with combination head are the same as for the head tube with 4-point head (**b** and **c** above).

g. Head Tube with 3-inch Minimum Diameter Head (3-point or 4-point) and Wedge Operating Rod. The 3-inch minimum diameter head assembly differs from the 5.75-inch minimum diameter head assemblies in having a head locking screw instead of a locking pin, with knob, assembly. Disassembly and assembly are the same as for the 5.75-inch minimum diameter heads except that the head locking screw is removed and installed, instead of a head locking pin, with knob, assembly.

h. Replacing One Head, with Outer Bearing, by Another Head, with Outer Bearing.

(1) Remove as a unit the head, which is to be replaced, wedge and wedge operating rod as described in **b** (1) through (6) above.

NOTE: If a 3-inch minimum diameter head is being replaced, the first step in (1) will be to unscrew and remove the head locking screw.

(2) "Spring" the movable carriers in the old head (the head which is being replaced) as follows: Install a measuring point securely in the movable carrier, pull out on the point and give the point a partial turn so that the carrier will be "locked" in the extended position (partly out of the head).

(3) Withdraw (back out) the wedge with wedge supporting collar.

(4) "Spring" the movable carriers in the new head by installing a measuring point in the carrier, extending the point and giving it a partial turn.

(5) Install the new head, with outer bearing, on the wedge.

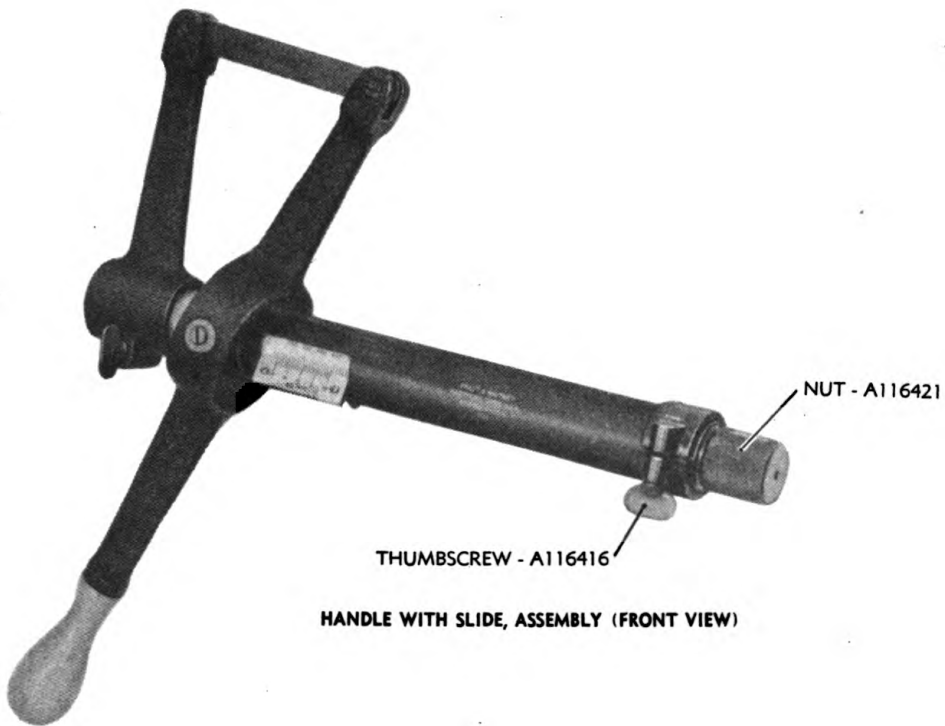
(6) "Lock" each movable carrier in place by giving the measuring point a partial turn.

(7) Unscrew and remove the measuring point.

(8) Reverse the steps described in **b** (6) through (1) above.

i. Extension Staff Assembly. The disassembly and assembly of the extension staff assembly are the same as for the 2-inch star gage (see par. 7 f).

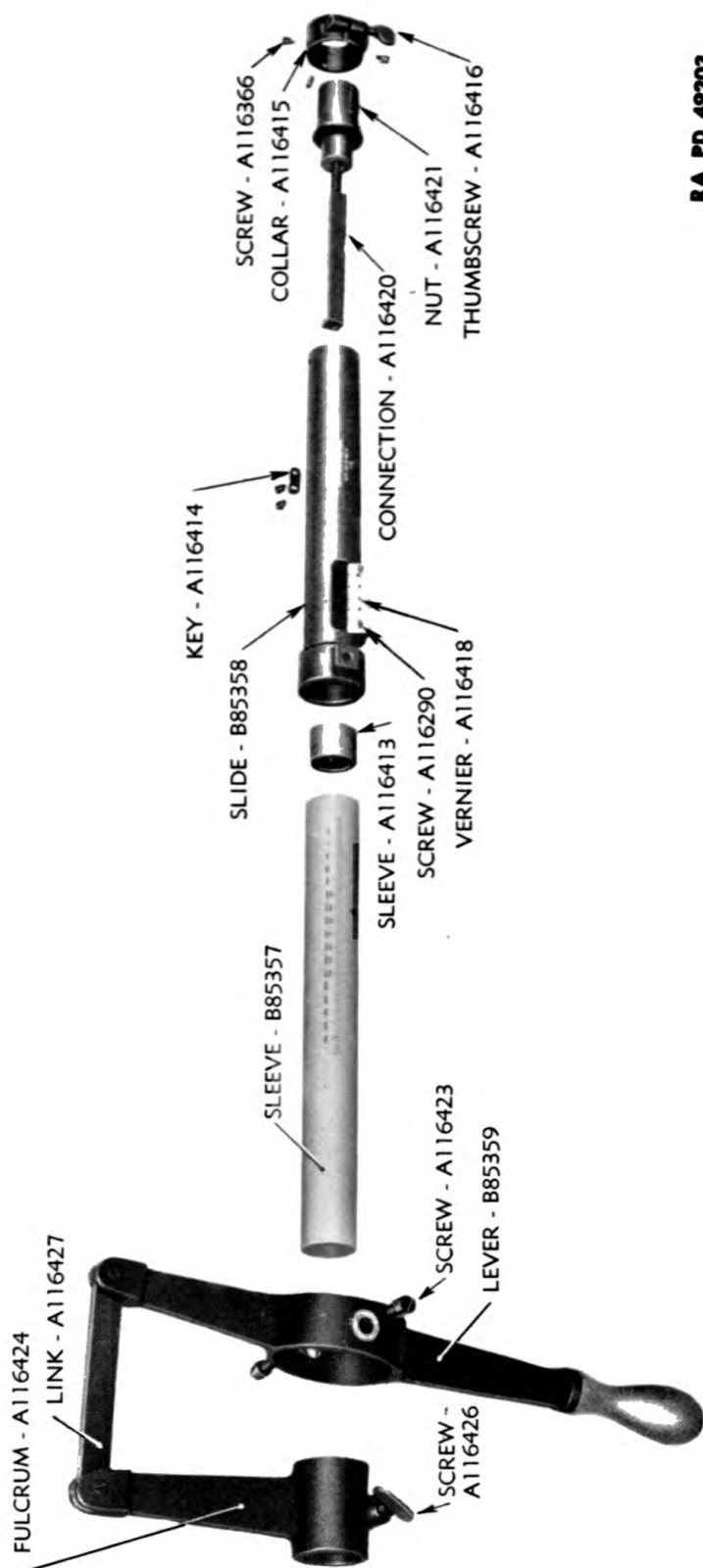
DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES



RA PD 49202

Figure 31—Handle, with Slide, Assembly (5.75-inch Star Gage)

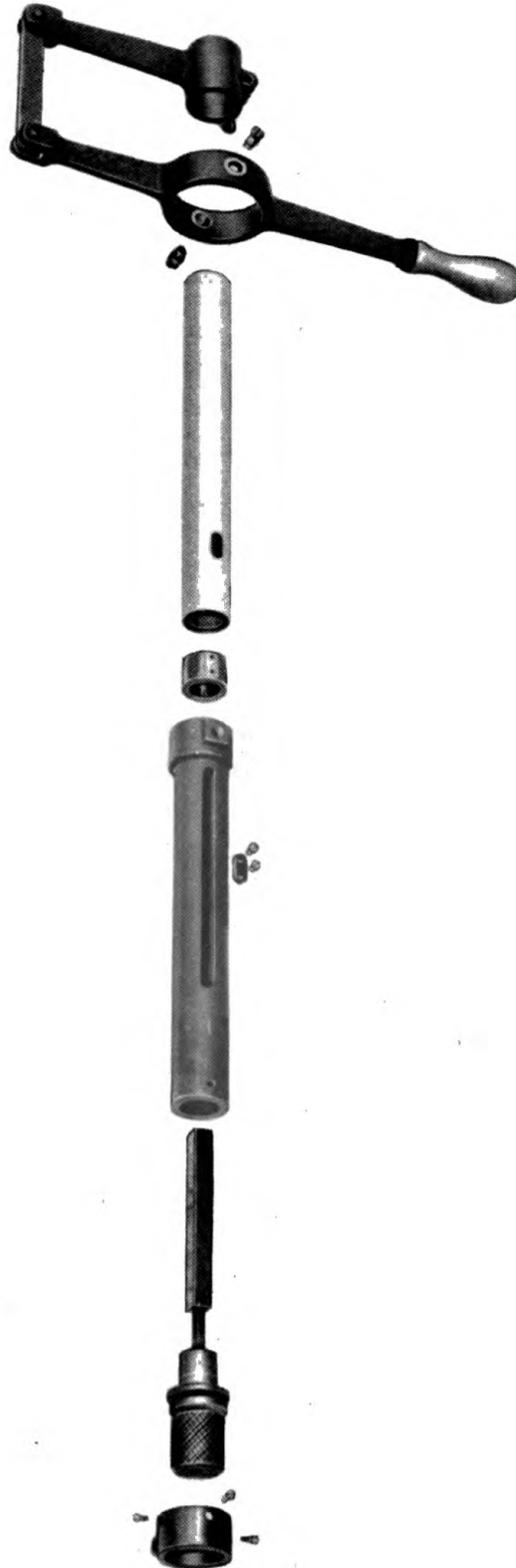
ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
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RA PD 49203

Figure 32—Exploded View of Handle, with Slide, Assembly (Front View, 5.75-inch Star Gage)

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Figure 33—Exploded View of Handle, with Slide, Assembly (Rear View, 5.75-inch Star Gage)

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j. **Handle, with Slide, Assembly** (figs. 31, 32 and 33). The handle, with slide, assembly of the 5.75-inch star gage differs from that of the other star gages in having a knurled vernier slide adjusting connection nut A116421 with clamping collar A116415 and a vernier sleeve key retaining sleeve A116413. The handle, with slide, assembly is disassembled as follows:

(1) Loosen screws A116426 which clamps fulcrum A116424 to the vernier sleeve.

(2) Using a suitable screwdriver, unscrew and remove the two trunnion collar screws A116423. Remove the lever, link and fulcrum as a unit.

(3) Loosen clamping collar thumbscrew A116416.

(4) Using a suitable screwdriver, unscrew and remove the three clamping collar screws A116366.

(5) Back off adjusting connection nut clamping collar A116415.

(6) Withdraw adjusting connection nut A116421 and adjusting connection A116420 as a unit.

NOTE: The word "UP" stamped on some of the connections A116420 pertains to a manufacturing operation. It has no significance for the disassembly or assembly of the handle, with slide, assembly.

(7) Using a small screwdriver, unscrew and remove the vernier sleeve key screws. Lift out vernier sleeve key A116414. **CAUTION:** Before removing key A116414, mark the key and vernier sleeve so that the key will be installed in the same position on reassembly.

(8) Withdraw vernier sleeve B85357 from vernier slide B85358.

(9) The key retaining sleeve A116413 may be withdrawn from vernier sleeve B85357 at this stage. If the retaining sleeve is withdrawn, it is located in place on assembly by vernier sleeve key A116414.

(10) Vernier A116418 can be removed from the slide after the two vernier screws A116290 are removed.

(11) To assemble the handle, with slide, assembly, reverse steps (10) through (1).

CAUTION: 1st—If the vernier was removed, care must be taken when installing the vernier to avoid scoring the sleeve. Hold the vernier slightly away from the sleeve with one hand while screwing the vernier screws A116290 with the other. 2nd—Check that vernier slide adjusting connection A116420 is screwed all the way home in adjusting connection nut A116421.

Section IV

ASSEMBLING THE STAR GAGE FOR OPERATION

	Paragraph
General	11
2-inch star gage	12
1.35-inch star gage	13
0.75-inch star gage	14
5.75-inch star gage	15
Gages equipped with assembling pins.....	16

11. GENERAL.

a. Star gages are assembled or made up for use by assembling the subassemblies—head tube, with head and wedge operating rod, extension staff and handle, with slide. The subassemblies generally are not disassembled before making up the gage unless it is necessary to remove the grease or COMPOUND, rust preventive, used in shipping or storing the gage. If necessary to remove grease or COMPOUND, rust preventive, disassemble the subassemblies as described in section III and clean the parts with SOLVENT, dry-cleaning. After the parts are dry, assemble the subassemblies.

b. The number of extension staff assemblies used depends on the length of the cannon to be gaged.

c. The head and the measuring points used depend on the number of lands and grooves in the cannon to be star-gaged. It will be necessary to change the head installed on the head tube in the following two cases:

(1) The gage is received with a 4-point head installed in the head tube and the number of lands and grooves in the cannon to be star-gaged is not evenly divisible by four.

(2) The gage is received with a 4-point head installed in the head tube, suitable offset points for the cannon to be gaged are not available and the number of lands and grooves is not evenly divisible by three.

CAUTION: 1st—The most important precaution to observe in assembling the gage is to make sure that the operating rods do not engage before the tubes engage. Any attempt to screw the tubes “home” in this case might cause a permanent twist of the operating rod and make the gage inoperable. 2nd—Use only a moderate pressure to seat the extension tubes. The graduations on the extension tubes are so placed that, when the gage is assembled, the graduations on two adjoining tubes do not quite mate up. This is so that, as the gage is used, wear will cause the graduations to line up better. 3rd—Check that the measuring points and the tapped recesses in the measuring point carriers are *entirely* free from oil and dirt.

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES****12. 2-INCH STAR GAGE.**

a. **General.** Assume that the 75-mm Gun M1916 is to be star-gaged. The table of cannon characteristics (Table I) shows that this gun has 24 lands and a length of rifling of 69.5 inches. The 2-inch star gage will be used. Either a 3-point or a 4-point head (number of lands being evenly divisible by three and four) may be used. Two extension staff assemblies will be used in order to have the handle several inches ahead of the muzzle during star-gaging measurements.

b. Assembling Head Tube, with Head, and First Extension Staff.

(1) Remove the assembled head tube with head, appropriate measuring points and wedge operating rod from the chest. Move the operating rod back and forth to check that the measuring points move in and out smoothly.

(2) Loosen the head coupling set screw to permit the head to swivel as it travels along the rifling.

(3) Remove the first extension staff assembly (37-inch to 72-inch graduations) from the chest. Check whether the operating rod moves back and forth smoothly in the extension tube.

NOTE: It may happen very rarely that the operating rod is "bowed" and will not translate smoothly in the extension tube. Remove the operating rod collar, after driving out the taper pin, and withdraw the operating rod (fig. 11). Note whether the operating rod is "bowed." If it is, support the rod on an edge, such as that of a table and straighten by hand. Reassemble the rod, tube and collar and again note the movement of the rod in the tube.

(4) Adjust two exterior rests (wooden or iron) to the same height (50 inches or so) and place the head tube on one rest and the extension staff on the other. Take care that the tubes do not slide off the rests during make-up.

(5) Pull the wedge operating rod rearward as far as it will go.

NOTE: The wedge operating rod must be maintained in this position during make-up. This may be accomplished either by removing the size-ring spider cap and having an assistant press the wedge rearward while the operator assembles the head tube and extension staff, or by installing the size ring, size-ring spider and size-ring spider cap, as shown in figure 34.

(6) Pull the extension operating rod rearward with one hand as far as it will go and slide the extension tube over the head tube bushing with the other hand. Press the extension tube forward slightly and at the same time rotate it slowly, about one-half turn, until a slight "click" is heard.

ASSEMBLING THE STAR GAGE FOR OPERATION



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Figure 34—Assembling Head Tube and Extension Staff (2-inch Star Gage)

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(7) Push the extension operating rod forward with one hand and screw the extension staff and head tube "home" with the other (fig. 34). Check whether the operating rods have engaged by translating the extension operating rod to the rear and noting whether the measuring points move.

(8) There should be no "gap" between the head tube and the extension tube, if the head tube was assembled properly and if the head tube and extension staff were made up properly. If there is a gap, correct as follows:

(a) Unscrew the extension staff from the head tube and repeat step (6). This time in step (6) rotate the extension tube about one-half turn more after the "click" is heard or about one full turn in all. Repeat step (7).

(b) If a gap is still present, the operating rod collar on the wedge operating rod probably was assembled incorrectly. Uncouple the extension staff and head tube. Remove the operating rod collar on the wedge operating rod, after driving out the taper pin, and install the collar properly. Make up head tube and extension staff and check the engagement of the operating rods by translating the extension operating rod and noting the movement of the measuring points.

(9) Note the alinement of the graduations on the head tube and extension tube. If the misalinement is slight, it may be disregarded (see CAUTION 2nd in par. 11). If the misalinement is large, it indicates a faulty unit which should be returned to Watervliet Arsenal.

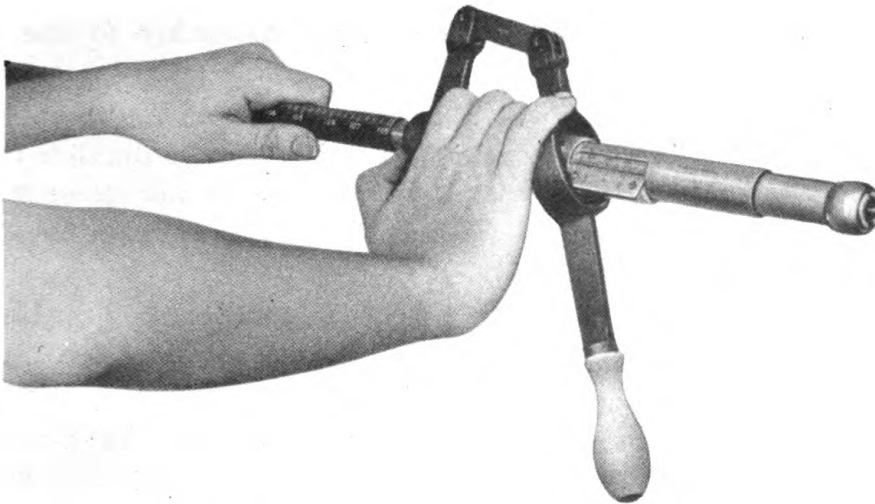
c. Assembling the Second Extension Staff Assembly to the First Extension Staff Assembly.

(1) Remove the second extension staff assembly (73-inch to 108-inch graduations) from the chest. Check whether the operating rod moves smoothly (see NOTE in b (3) above).

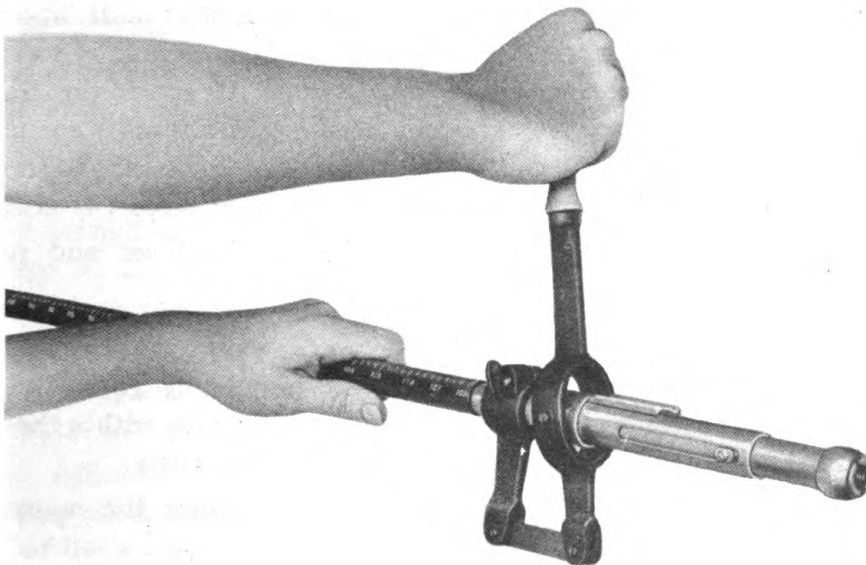
(2) Place the extension staff on an exterior rest which is in line with and at the same level as the other two exterior rests. Assemble the second extension tube and operating rod to the first extension tube and operating rod by sliding the second tube over the exposed bushing of the first tube. Engage the tubes and operating rods and screw the two tubes "home," as described in b above. Observe the alinement of the graduation on the two tubes (see CAUTION 2nd in par. 11).

d. Mounting the Gage Supports. Gage supports (figs. 43A and 43B) are used to center the star gage in the bore of the cannon. Metal gage supports or wooden gage supports are used. One support is mounted at about the 6-inch graduation on the head tube and additional supports are installed at intervals of about 4 feet. If metal gage supports are used, they are clamped on after the gage is assembled.

ASSEMBLING THE STAR GAGE FOR OPERATION



A — ENGAGING VERNIER SLEEVE AND EXTENSION TUBE



B — ENGAGING VERNIER SLIDE ADJUSTING CONNECTION AND EXTENSION OPERATING ROD

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Figure 35—Assembling Handle, with Slide, Assembly to Last Extension Staff (2-inch Star Gage)

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If wooden gage supports are used, they are slipped over the last extension staff before the handle, with slide, assembly is assembled to this staff.

e. Assembling the Handle, with Slide, Assembly to the Last Extension Staff (fig. 35).

(1) Remove the handle, with slide, assembly from the chest. Move the handle back and forth a few times and note whether the slide moves freely over the sleeve. If necessary, wipe off the vernier sleeve with a clean cloth, saturated with OIL, clock, or OIL, lubricating, preservative, light.

(2) Holding the lever as far to the rear as possible, slide the handle, with slide, assembly over the bushing of the extension tube as far forward as possible (A, fig. 35).

(3) Press the handle forward slightly and rotate the handle, about one-half turn, until a slight "click" is heard, indicating that vernier sleeve and extension tube have just engaged.

(4) Move the lever grip forward to engage the vernier slide adjusting connection and the extension operating rod (B, fig. 35).

(5) Screw the handle, with slide, assembly home.

(6) If a gap is present after seating the handle, with slide, assembly as far as it will go, the vernier sleeve and the extension tube were not sufficiently engaged when step (4) was started. Unscrew the handle, with slide, assembly from the extension staff assembly and repeat step (3). This time rotate the handle about one-half turn more after the "click" is heard or about one full turn in all. Repeat steps (4) and (5).

(7) Check the gage make-up by operating the lever and noting the movement of the measuring points.

f. Making the Vernier Zero Setting.

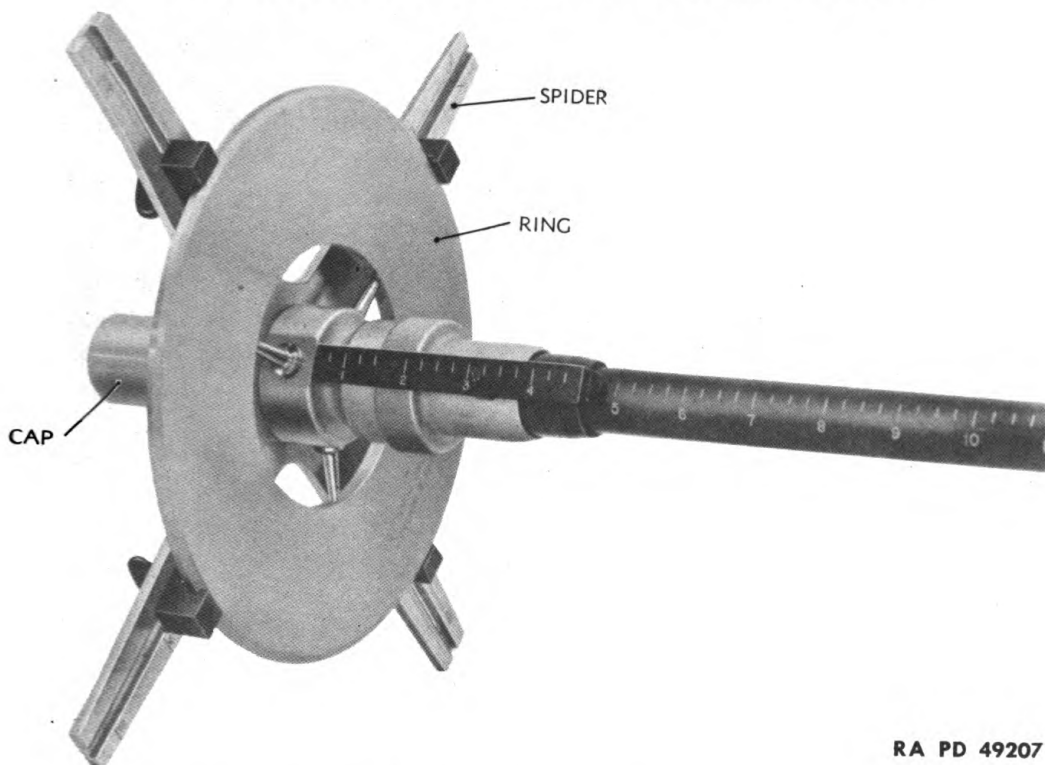
(1) Select the size ring stamped for the gun being gaged, wipe it clean and inspect for burs. Install the size ring centrally within the jaws of the size-ring spider, and tighten the thumbscrews lightly.

(2) Move the vernier handle to the rear to cause the measuring points to retract to their minimum diameter position.

(3) Place the spider, with size ring, on the forward shoulder of the gage head and retain it in place by installing the size-ring spider cap (fig. 36). Move the vernier handle forward until *all* the measuring points are snugly in contact with the bore of the size ring.

CAUTION: For accurate zero setting, the size ring must be perpendicular to the axis of the gage. To check this, the assistant rotates the ring to several positions about the gage head as an axis and notes whether the measuring points remain in contact with the ring. When

ASSEMBLING THE STAR GAGE FOR OPERATION



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Figure 36—Size Ring and Size-ring Spider Installed on 2-inch Star Gage

the assistant has verified that the size ring is perpendicular to the axis of the gage, he tightens the spider jaw thumbscrews and screws the size-ring spider cap securely against the spider.

(4) The operator notes the direction of variation between the zeros on the vernier and sleeve. If the zero on the flat vernier is forward of the zero on the sleeve, the slide must be moved rearward. If the zero on the flat vernier is to the rear of the zero on the sleeve, the slide must be moved forward.

(a) Using the special teat wrench (large end), loosen the adjusting connection nut locking screw A116281 slightly (figs. 16 and 18).

(b) Adjust the zeros by screwing, or unscrewing, as necessary, the adjusting connection nut A116280 with the special teat wrench (small end), at the same time pressing the handle forward.

(c) Tighten the locking screw A116281 with the special teat wrench (large end). Check whether the zero setting has changed.

CAUTION: If locking screw A116281 was completely unscrewed in step (4) (a) above, the zero setting will change when this screw is tightened in step (4) (c) above and it will be necessary to repeat the adjustment.

(d) Unscrew and remove the size-ring spider cap and remove the spider, with size ring.

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Figure 37—Size-ring Spider Cap, Rifling Guide and Star Gage (2-inch Star Gage)

ASSEMBLING THE STAR GAGE FOR OPERATION

(e) Move the handle forward to check whether a plus reading of at least 0.030 inch is possible. Reading the vernier is described in paragraph 17 e. If the vernier sleeve will not move sufficiently to give plus readings of at least 0.030 inch, the gage was made up improperly or the operating rod collar on the wedge operating rod or on an extension operating rod was installed improperly. To locate the trouble, dismantle the gage and repeat the make-up, this time assembling the handle, with slide, assembly to the first extension staff assembly. Then, if necessary, disassemble the extension staff or head tube and inspect the operating rod collar.

g. **Installing the Rifling Guide.** Install the proper rifling guide, with the arms of the guide directed toward the measuring points, and install the spider cap (fig. 37). See paragraph 29 for a description of rifling guides.

h. Dismantling the Gage.

(1) Unclamp and remove the metal gage supports if these supports were used.

(2) Unscrew the handle, with slide, assembly from the last extension staff.

(3) Unscrew the two extension staves.

(4) Unscrew the head tube from the first extension staff.

(5) Unscrew and remove the size-ring spider cap and remove the rifling guide. Replace the cap to protect the wedge.

CAUTION: The most important precaution to observe in dismantling the gage is to make sure that the extension staves and head tube do not slip off the exterior rests. The assistant should "steady" the gage while the operator dismantles it.

13. 1.35-INCH STAR GAGE.

a. The 1.35-inch star gage is used chiefly for the 37-mm, 40-mm and 57-mm guns (see Table I). The assembly or make-up of this gage for star-gaging and the adjustment of the vernier zero are the same as for the 2-inch gage (par. 12).

14. 0.75-INCH STAR GAGE.

a. This gage is provided with a 4-point head (sometimes called a 2-point head) and a 3-point head. At present, the 0.75-inch gage is used principally to star-gage the 20-mm automatic gun which has nine lands and grooves. Hence, if the gage is received with the 4-point head installed in the head tube, it will be necessary to replace this head with a 3-point head (see par. 9 e).

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b. After the proper head has been installed in the head tube, the make-up of the gage for star-gaging is the same as for the 2-inch gage except that one extension staff assembly only is used for the 20-mm gun. The adjustment of the vernier zero is the same as for the 2-inch gage (par. 12 f).

15. 5.75-INCH STAR GAGE.

a. The make-up of the gage is the same as for the 2-inch star gage. The adjustment of the vernier zero setting is slightly different. The operator or assistant installs the proper measuring points, after wiping off the shoulders of the points, if necessary, so that they will screw "home" without forcing. The operator loosens the clamping thumbscrew A116416 slightly, rotates the adjusting nut A116421 until the zeros on the vernier sleeve and vernier scale aline and then tightens thumbscrew A116416 (fig. 31). The 5.75-inch star gages are not provided with size-ring spiders suitable for the larger size rings. Hence, when large chambers are to be gaged, it is necessary for an assistant to hold the size ring on the head while the operator sets to zero.

b. In adjusting the vernier zero setting for the 3-inch minimum diameter head, the wedge should be extended as far forward as possible. The design of this head at present is such that minus readings will *not* be possible if the vernier is adjusted to zero with the point carriers approximately midway along the wedge, as is the usual case in making the vernier setting with the other heads.

CAUTION: If several extension staves are assembled, care will be necessary to make sure that the staves are at the same level and in line. If the staves are out of line, the gage will not make up properly. The levelness of the assembled tubes should be checked by placing a level at two or three positions on the partially assembled staves. The line-up of the staves is checked by sighting.

16. GAGES EQUIPPED WITH ASSEMBLING PINS.

a. Some of the smaller star gages are equipped with an assembling pin which drops down through the tube and the operating rod of each staff and locates the operating rod in a fixed position with respect to the tube. To assemble the gage, make sure that the assembling pins are in the handle, with slide, assembly, in the head tube and wedge operating rod and in each extension staff assembly. The gage is made up by screwing the assemblies together. The pins are then removed and the gage is ready for use.

Section V

STAR-GAGING CANNON

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17. GENERAL.

a. Table I lists the star gages used with different cannon. In the listing of applicable star gages in Table I, it is assumed that the vernier will be set to "zero" in the appropriate size ring with no washers or distance pieces installed on the measuring point carriers. Other gages than those indicated for a particular cannon can be used. For example, the 1.35-inch gage can be used to gage the 60-mm mortar by setting the vernier to zero (60 mm) with suitable washers installed on the carriers. Also, the 1.35-inch gage could be set to zero (60 mm) without using washers by sufficient adjustment of the vernier slide adjusting connection nut. However, if washers are not used in making the zero setting, the total possible travel of the carriers on the wedge corresponding to plus values will be less than it would be if washers were used.

b. Star-gaging may be done in a shop or in the open. Accurate measurements may be made both in warm and moderately cold weather. However, the star-gaging schedule should be planned to avoid a large variation in temperature during measurements. It is not practical to star-gage in the open during misty or rainy weather because the gage may be damaged. If star-gaging is performed in the open during a strong wind, means must be provided to prevent the exterior rests from blowing over.

c. Cannon are star-gaged with the cannon mounted in a horizontal position. Measurements are usually made at every 1 or 2 inches along the bore of field cannon, including the 105-mm howitzer and the 155-mm howitzer. Cannon of larger caliber are measured at 5-inch intervals, decreasing the intervals to 2 inches when within one and one-half times the length of the projectile from the origin of rifling. Short chambers are measured at each inch or half inch and larger chambers at each 2 inches of length.

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WA 56a

Measurements of Lands and Grooves.

Set

Lands.

Set

Grooves.

.....inch.....No.

Model of.....

INCHES FROM MUZZLE	LANDS			GROOVES		
			MEAN			MEAN
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
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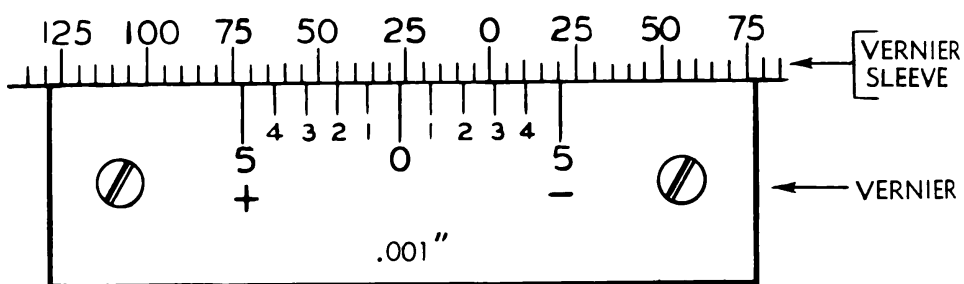
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Figure 38—Star-gage Record Form Used at Watervliet Arsenal for All
Calibers from 20 mm to 16 inches

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d. An operator and one or two assistants usually work together in star-gaging a cannon. One assistant stands at the muzzle and notes the distance which the gage has advanced into the bore. The second assistant, if there is one, records the vernier scale readings called off by the operator and the distances called off by the other assistant on the star-gage record form (figs. 38 and 39). If there is only one assistant, the operator will usually record the star-gaging data.

e. The vernier sleeve is calibrated in thousandths of an inch. To obtain the vernier scale reading, note which sleeve graduation comes closest to coincidence with the zero on the small, flat scale and add, or subtract, the vernier graduation which fully alines with a graduation on the sleeve. For example, see figure 40. As the "25" graduation on the sleeve is nearest to being in true alinement with the "0" on the vernier, the *rough* reading of the difference in diameter between the position being gaged and the size ring in which the gage was set to zero is 0.025-inch. The reading is "plus" because the "0" on the sleeve is to the right of the vernier "0"—to the left would indicate a "minus" reading. The more exact value of the third (thousandth) decimal place is obtained by noting that the vernier graduation *plus* "2" is fully alined with a graduation on the sleeve. Hence, the fine reading of the difference in diameter between the position being gaged and the initial zero setting is + 0.027 inch.



(READING: +.027)

RA PD 49210

Figure 40—Vernier Sleeve and Vernier

f. Plus readings mean an increase in diameter and are indicative of erosion or local defects such as pastilles, pits, gouges, etc. (par. 23 e). Minus readings mean a decrease in diameter and are indicative of coppering or local defects such as burs. Apart from local defects, worn guns generally give plus values for the first third of the bore, due to erosion at and near the origin of rifling, negative values for the middle third, due to coppering, and plus values for the last third, due to erosion near the muzzle.

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18. GETTING THE "FEEL" OF THE GAGE.

a. Some operators find it convenient to turn the handle lever around so that the handle is directed away from the operator (fig. 41B). Apply pressure to the lever by cupping the fingers loosely around the ball end of the handle and pushing until the handle slides into the palm of the hand. The measuring points should feel to be in firm contact with the bore being measured before the ball end slides into the palm, but excessive pressure should not be applied. This method gives sufficient pressure to the measuring points, while at the same time helps to develop a "feel" of the gage.

19. STAR-GAGING A CANNON BORE.

a. **Gage with 3-point Head.** The measurements are made from the muzzle end if possible. Normally measurements will be made only of the lands. A convenient routine procedure for making the measurements is as follows: 1st—Install the gage head in the bore with one measuring point on the 6 o'clock land at the muzzle and measure the lands starting at the muzzle end and proceeding to the origin of rifling. 2nd—Measure the lands starting at the origin of rifling and proceeding to the muzzle end of the bore. The detailed steps are:

(1) To prepare the gun for star-gaging, clean the bore and chamber thoroughly.

(2) Mount as many exterior rests as needed forward of the muzzle and in line with the axis of the bore. Place one rest 1 or 2 feet from the muzzle of the gun and the others at intervals of about 5 feet. Clamp the rests firmly at the same height as that of the cannon bore.

(3) Place the assembled star gage on the rests with its head near the muzzle. If necessary, adjust the vernier zero, using the proper size ring, and install the rifling guide.

(4) Check whether the star-gage head revolves freely. If it does not, loosen the head coupling set screw, or if the 5.75-inch gage is being used, pull out the locking pin knob and rotate it sufficiently to hold the locking pin in the extended position.

(5) Retract the measuring points by pulling the operating lever to the rear.

(6) Move the gage into the bore until the rifling guide is a short distance in the bore. Adjust the rifling guide so that the measuring points bear against the center of the lands and slightly tighten the size-ring spider cap against the guide (0.75-inch, 1.35-inch and 2-inch gages). Carefully back the gage out of the muzzle and tighten the cap against the guide firmly.

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(7) Move the star gage slowly into the bore, stopping at the distance shown on the record form for the first measurement. In the case of the 37-mm Gun M1916, the record form (fig. 39) requires that the first measurement be made at $\frac{1}{8}$ inch from the muzzle. The assistant holds a short steel scale against the star-gage head with the zero edge of the scale at the location of the measuring points and tells the operator when the $\frac{1}{8}$ -inch graduation on the steel scale lines up with the muzzle face.

(8) Move the lever of the vernier slide forward until the measuring points are in firm contact with the lands (see par. 18). Note the reading on the vernier. Release the lever and then move it forward again to get a check reading. Repeat until two readings agree and record this reading on the star-gage record form.

(9) Release the lever and carefully guide the star gage along the bore to the next measuring position shown on the record form and proceed as in (8).

(10) Continue taking measurements along the bore until the gage head reaches the origin of rifling.

CAUTION: 1st—At no time will force be used to advance the star gage through the bore. 2nd—The operator should take care that the gage head does not run off the rifling, because it may be difficult to work the head back on the rifling again. When gaging large guns, it may be convenient to install a stop on the gage staff at a distance equal to the length of rifling.

(11) After measuring the diameter of the lands at the origin of rifling, back up the gage head approximately to the next to the last position measured and repeat the measurement at this position. Continue withdrawing the gage and taking measurements until the measuring points are approximately at the first position measured.

(12) Withdraw the gage completely from the bore. Remove the spider cap and rifling guide and check the zero setting of the vernier in the size ring. If the zero reading does not check, it will be necessary to repeat the entire set of measurements.

NOTE: In figure 41A the assistant is shown using a flat-edged stick as an index against which he reads the scale graduations on the head tube and extension tubes.

(13) If it is necessary to measure the grooves, carry out steps (5) through (12) above, taking care in step (6) to have the measuring points bear against the center of the grooves. Generally, a rifling guide will not be necessary. (Compare paragraph 29.)

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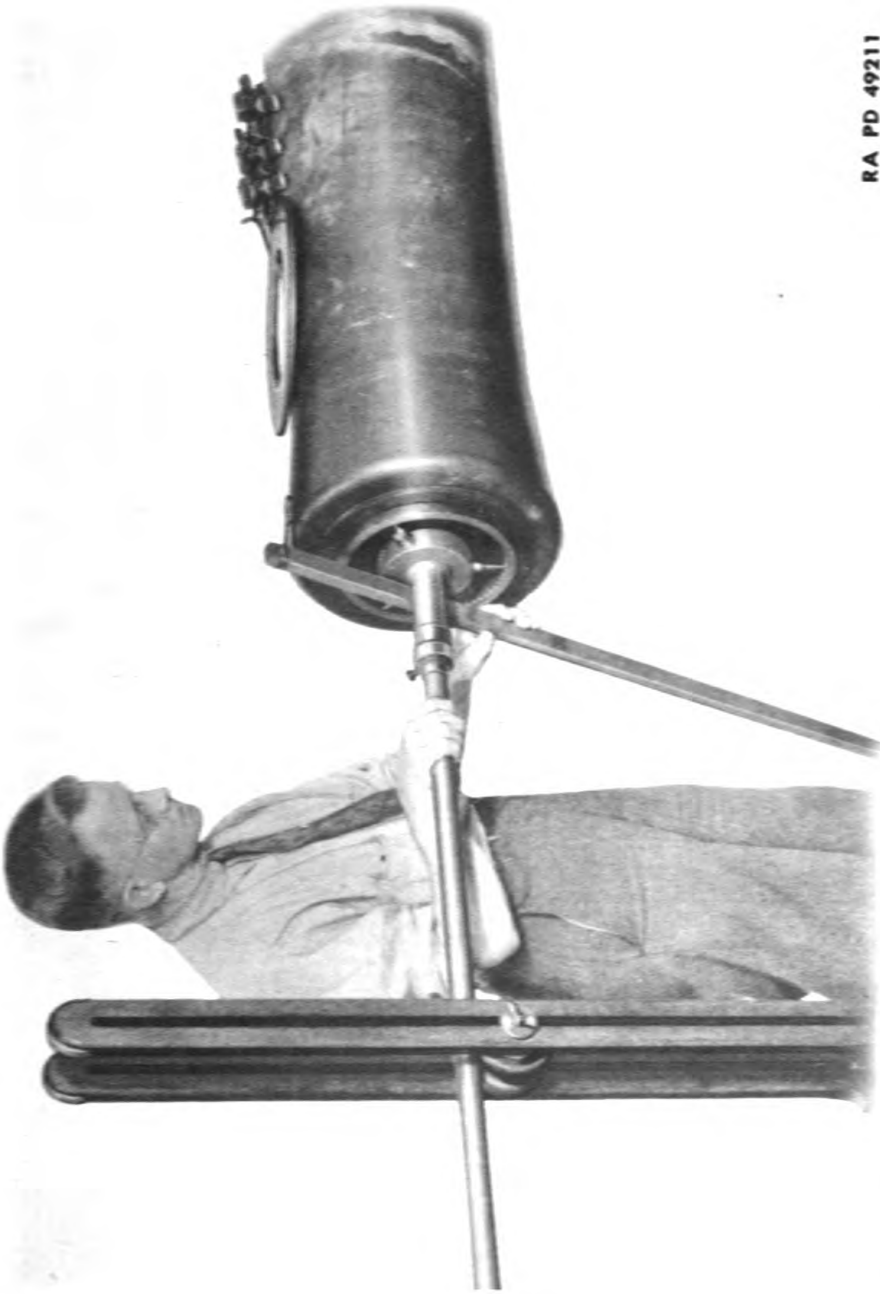


Figure 41A—Star-gaging the Grooves of an 8-inch Gun, Mark VI, from Muzzle End (First Measurement)

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Figure 41B—Star-gaging the Grooves of an 8-inch Gun, Mark VI, from Muzzle End (Gage Partly Advanced in Bore)

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(14) If it should be necessary to star-gage a cannon from the breech end, a centering device or breech rest may be used (fig. 45). In cannon of large caliber, an extra extension staff will be required. The location of the position being gaged is determined by reading a graduation on the gage scale against an edge of the breech rest. Diameter measurements are made by guiding the gage through the bore (from the breech end) until the first position to be measured (near the muzzle) is reached. The remaining positions called for on the star-gage record form are measured by withdrawing the gage through the breech end.

b. Star Gage with 4-point Head.

(1) The same procedure may be used as for the 3-point head (par. 19 a). An alternative procedure is sometimes used with the 4-point head when gaging guns that are highly eroded near the origin of rifling. The measurements are referred to the lands and grooves at 12 o'clock and 6 o'clock (for the vertical measurements) and at 9 o'clock and 3 o'clock (for the horizontal measurements) at the origin of rifling.

(2) The position of the lands at the muzzle which at the origin of rifling are at 12 o'clock and 6 o'clock may be determined as follows: The operator estimates the twist of rifling and installs the rifling guide so that the measuring points are on the lands. The operator carefully guides the gage through the bore until the measuring points are at the origin of rifling. The assistant observes the position of the rifling guide from the breech end and reports it to the operator. The operator backs the gage out of the bore through the muzzle end and adjusts the rifling guide and the gage head so that the first measurement at the muzzle corresponds to the 12 o'clock-6 o'clock setting at the origin of rifling.

(3) After the vertical and horizontal measurements are made on the lands, similar measurements may be made on the grooves. The grooves measured are those next to the lands—to the right, as seen from the muzzle.

c. **Star-gaging Cannon Near the Origin of Rifling.** In cannon where the end of the accuracy life has almost been reached, the erosion at and near the origin of rifling may have obliterated the lands and grooves. In such cases, the rifling guide will fail to guide the measuring points properly. In cannon having a bore of 14 inches or larger, a man may partly enter the chamber and hold the measuring points on the lands, or in the grooves, for the required measurements. For cannon having a bore of less than 14 inches, the diameter measurements are obtained by shortening the star gage to the minimum number of staves required and taking the measurements from the breech end, if possible. By rotating the star gage slightly to the right or left, the operator is able to find the largest diameter on the lands, as well as the smallest

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diameter in the grooves, at the distances required for the star-gage record form.

d. **Metal Accumulations.** Metal accumulations from the rotating bands of projectiles often will be found in the grooves, beginning forward of the erosion (near the origin of rifling) and extending to the muzzle face. Pronounced accumulations may occur midway in the bore. This condition will be indicated by a spongy feel at the handle of the gage. The diameter measurements will not always correspond to the maximum values.

20. STAR-GAGING A CANNON CHAMBER.

a. Cannon chambers are generally star-gaged from the breech end. After the bore has been gaged, extension staves are removed, leaving only a sufficient number to gage the chamber. Generally only the head tube with head and wedge operating rod and the handle, with slide, assembly will be needed. No gage supports are used in chamber measurements. Either two sets of measurements, one each for the vertical and horizontal diameters, or one set of measurements is made.

b. Straight Chamber.

(1) Consult the star-gage record form or the chamber drawing to ascertain the calibrated diameters. (See also Table I.)

(2) Select the appropriate size ring, measuring points and spacing washers to correspond to the diameter of the chamber. Assemble the washers and points to the point carriers.

NOTE: In replacing the points for the chamber measurements, the star-gage head is not removed from the gage. The points used for the bore measurements are removed from the carriers, using the special teat wrench or, in the case of the 5.75-inch gage, the $\frac{9}{16}$ -inch end wrench, and the chamber measuring points are installed with the same wrench, after the spacing washers have been put in place.

(3) Install the size ring on the gage head and make the zero setting. Operate the lever to cause the tips of the measuring points to bear firmly on the inner periphery of the size ring and adjust the vernier slide connection nut to bring the zero of the moving scale into coincidence with the zero of the fixed scale (par. 12 f or par. 15 a). Lock the head against swiveling by tightening the head coupling set screw or, if a 5.75-inch gage is being used, by rotating the locking pin knob so that the locking pin is in the closed position. Remove the size ring.

NOTE: In general, size rings exactly equal to the maximum and minimum chamber diameters are not available. In this case, a convenient procedure is to compute the difference between the size-ring bore and the minimum chamber diameter (by subtraction) and to set

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the vernier in the size ring to this difference. The vernier readings in the actual chamber measurements will then be variations from the minimum chamber diameter. For example: A size ring of 3.08-inch bore is available and the minimum chamber diameter to be measured is 3.1 inches. Install the size ring on the gage and adjust the vernier setting to read $-.02$ when the measuring points bear against the bore of the size ring. Remove the size ring. The vernier will then read zero when the gage is installed at the position of minimum diameter (3.1 inches) in the chamber.

(4) Place an exterior rest about one foot to the rear of the breech and place the star gage on the rest with its head near the breech.

(5) Retract the measuring points fully and insert the star gage in the chamber.

(6) Guide the gage to the first position called for on the star-gage record form. Move the operating lever forward until the points bear firmly against the chamber walls. Note the vernier reading. Release the lever and move it forward again to obtain a check reading. Record the reading on the star-gage record form. Release the lever, move the gage to the second position called for on the record form and obtain the reading at this position. Continue in this manner until all the readings called for have been recorded.

NOTE: Some operators attach a centering device (fig. 45) to the breech face when gaging a cannon chamber with a 5.75-inch star gage. If a centering device is used, the scale markings on the gage tube are read against the rear face of the centering device. Hence it is necessary to measure the distance between the rear face of the centering device and the breech face and subtract this distance from that read on the gage scale to determine the advance of the gage in the chamber.

(7) Take a second series of measurements, this time starting from the forward or muzzle end of the chamber and proceeding to the breech end.

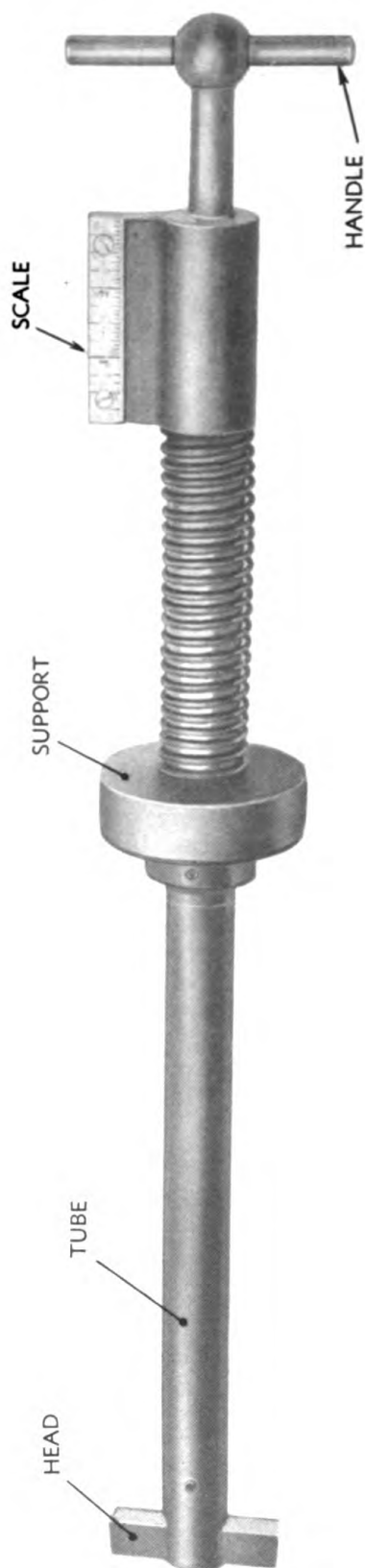
(8) Withdraw the gage from the chamber and check the zero setting in the size ring.

c. "Bottleneck" Chamber.

(1) Cannon chambers which have a relatively small diameter at the gas check seat are referred to as "bottleneck" chambers. The 6-inch Gun M1900, and the 155-mm Gun M1920M1 are of this type (See Table I.) When star-gaging this type of cannon, two or more breakdown or hinged points (fig. 6A) and distance pieces (fig. 50) are used.

(2) Install the hinged points with distance pieces suitable for the chamber diameter in the star-gage head. Mount the size ring on the head, make the zero setting and remove the size ring. Turn down the

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Figure 42—Forcing Cone Gage for 75-mm Gun (French)

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hinged points, insert the gage head into the chamber past the gas check seat, and snap the points back into position for measuring.

(3) Proceed with the chamber diameter measurements precisely as in the case of a straight chamber.

CAUTION: Make sure the hinged points are turned down before withdrawing the gage from the chamber at the conclusion of the measurements.

d. Tapered Chamber. When measuring a tapered chamber, it is very important that the measurements be taken at the exact distances from the breech face given on the star-gage record form or the chamber drawing.

(1) If the range of the first points used is insufficient to measure all the diameters of the taper, substitute larger measuring points and/or additional spacing washers and reset the vernier to zero with a second (larger) size ring.

(2) It will be necessary to take check readings with great care because the measuring points may slip slightly. In general, the diameter measurements will be only approximately correct.

21. ADVANCE OF FORCING CONE.

a. The advance of the forcing cone is a special bore measurement. It is always required on the star-gage record. The advance of the forcing cone may be measured by means of a forcing cone gage or by means of a projectile. Specific information on the maximum limits of advancement of the forcing cone will be distributed as soon as available.

b. Forcing Cone Gage.

(1) A forcing cone gage is available for each cannon from the 37-mm to the 155-mm gun inclusive. The gages are shipped as single units. The gages will not be disassembled. They consist of a T-shaped head at the forcing cone end, a tube, a support, a handle integral with the tube, and a scale. The support centers the gage in the chamber. Some of the gages are provided with a spring which is partially compressed by the support when the gage is installed in the cannon (fig. 42). The zero graduation of the gage scale is the normal distance from the face of the breech to the forcing cone.

(2) The maximum vertical advance of the forcing cone is measured by installing the forcing cone gage in the cannon with its head vertical, and the maximum horizontal advance of the forcing cone is measured by installing the gage with its head horizontal. Install the gage in the tube from the breech end and rotate the handle *slightly* about a horizontal axis until the gage head feels to be as far forward as possible. The advance of the forcing cone is equal to the reading of the gage

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scale, in fractions of an inch, which lines up with the face of the breech ring.

NOTE: The forcing cone gage currently used with the 40-mm Gun M1 cannot be installed through the breech ring. In this case it is necessary to remove the breech ring before installing the gage. The advance of the forcing cone is equal to the reading of the gage scale which lines up with the breech face of the tube.

c. Projectile.

(1) Shove the projectile into place with the usual force and measure the distance from the rear face of the projectile to the rear edge of the chamber with a steel scale. Repeat with one or two different projectiles. The advance of the forcing cone is equal to the measured distance minus the normal distance from the face of the projectile to the edge of the chamber as given in the cannon drawings.

(2) The advance of the forcing cone measured with a projectile is generally more than that measured with a forcing cone gage.

22. STAR-GAGE RECORDS.

a. All cannon, including guns, howitzers and mortars in service, shall be star-gaged at approximately 10 percent and 90 percent of their estimated average accuracy life in rounds fired, and thereafter at each 10 percent during the remainder of their service. Also, they should be star-gaged at any time an inspector may deem it necessary on account of doubtful conditions, or when the bore shows signs of unusual wear or other irregularities. Decoppering of the bores of cannon before star-gaging is prohibited.

b. A copy of all star-gage reports will be furnished the Chief of Ordnance. The reports should give, in addition to the star-gage record, the date, caliber, model, serial number, manufacturer and year of manufacture of the cannon star-gaged, the number of rounds fired, advance of forcing cone and any other pertinent data or remarks.

c. Record of all star-gaging will be entered in the gun book assigned to the respective cannon, in accordance with the instructions in the gun book.

23. CONDEMNATION LIMITS AND STAR-GAGING DATA.

a. Star-gaging data on service guns constitute part of the information needed to determine the remaining accuracy life of the guns. No rules of thumb can be given which state condemnation limits in terms of star-gaging data alone. A gun is still serviceable despite numerous bore defects if its dispersion is not so great as to endanger troops during a barrage or to cause excessive waste of ammunition.

STAR-GAGING CANNON

b. If circumstances permit, certain general principles are used in determining whether guns—including the 75-mm French guns—will be condemned.

(1) Erosion near the origin of rifling causes a decrease in pressure and velocity and, if the rifling is nearly obliterated, the projectile may have an improper rotation and inaccurate flight.

(2) If a cannon bore is dilated due to a "premature," the cannon is considered unsafe and should be reported to the Chief of Ordnance. If the bore has a gouge, the decision on the continued safe use of the cannon will depend on the observed accuracy of fire.

(3) Local defects of the bore, such as scratches, nicks, pitting, scoring, etc., cannot be passed on by any definite rule. Such defects permit leakage of gas which causes erosion of the bore and may cause such deterioration of the rotating band that the projectile does not acquire its proper rotation. The decision on the injuriousness of such defects is made on the basis of their location, character and extent. Local defects near the origin of rifling or near the muzzle are considered particularly injurious.

c. Considerable data have been accumulated on the 75-mm French guns, and the following general rules have been established for these guns. (See TM 9-1305.)

(1) It has been found generally true that when the diameter of the lands at the origin of rifling has increased 0.025 inch, the gun has reached the end of its accuracy life. Also, when the forcing cone gage shows the advance of the forcing cone to be one-fourth of an inch (0.25 inch), and the gun exhibits the usual amount of other defects, it should be condemned.

(2) The effect of *pastilles* upon the safety and accuracy of the gun is negligible so far as can be determined. It is realized, however, that definite facts are lacking and that the presence of pastilles is disquieting to the battery personnel. A gun with more than three pastilles should be reported to the Chief of Ordnance.

NOTE: The word *pastille* describes a condition where the tops of the lands have been forced down or indented probably by something coming between the tops of the lands and the shell while the latter was going through the bore.

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Section VI

ACCESSORIES

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Size-ring spiders	31
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24. GENERAL.

a. Accessories for star gages include tools and equipment required for the disassembly and assembly that may be performed by qualified ordnance maintenance personnel in the field and for the cleaning and preservation of the materiel. They also include chests and other items necessary to protect the materiel when it is not in use, or when traveling. Accessories should not be used for purposes other than those prescribed, and when not in use should be properly stored.

25. RECORDS.

a. **Star-gage Record.** When completed, the star-gage record sheet or form is the permanent record of the measurements of the cannon by serial number after a specified number of service rounds.

b. Artillery Gun Book.

(1) The gun book (0.0. Form 5825) is used to keep an accurate record of the materiel and remains with the piece regardless of where it may be sent. It includes records of assignments, the battery commander's daily record and the inspector's record of ammunition, as well as forms to be filled out in case of premature explosions. This book should be in the possession of the organization at all times. It is the sole responsibility of the organization commander as to the completeness of the record and as to the whereabouts of the book. It must also contain the date of issuance of the materiel, to and by whom issued

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and the place where issued. If a new cannon is installed on the carriage, all data in the old book with reference to sights, carriage, etc., must be copied into the new gun book before the old gun book is relinquished.

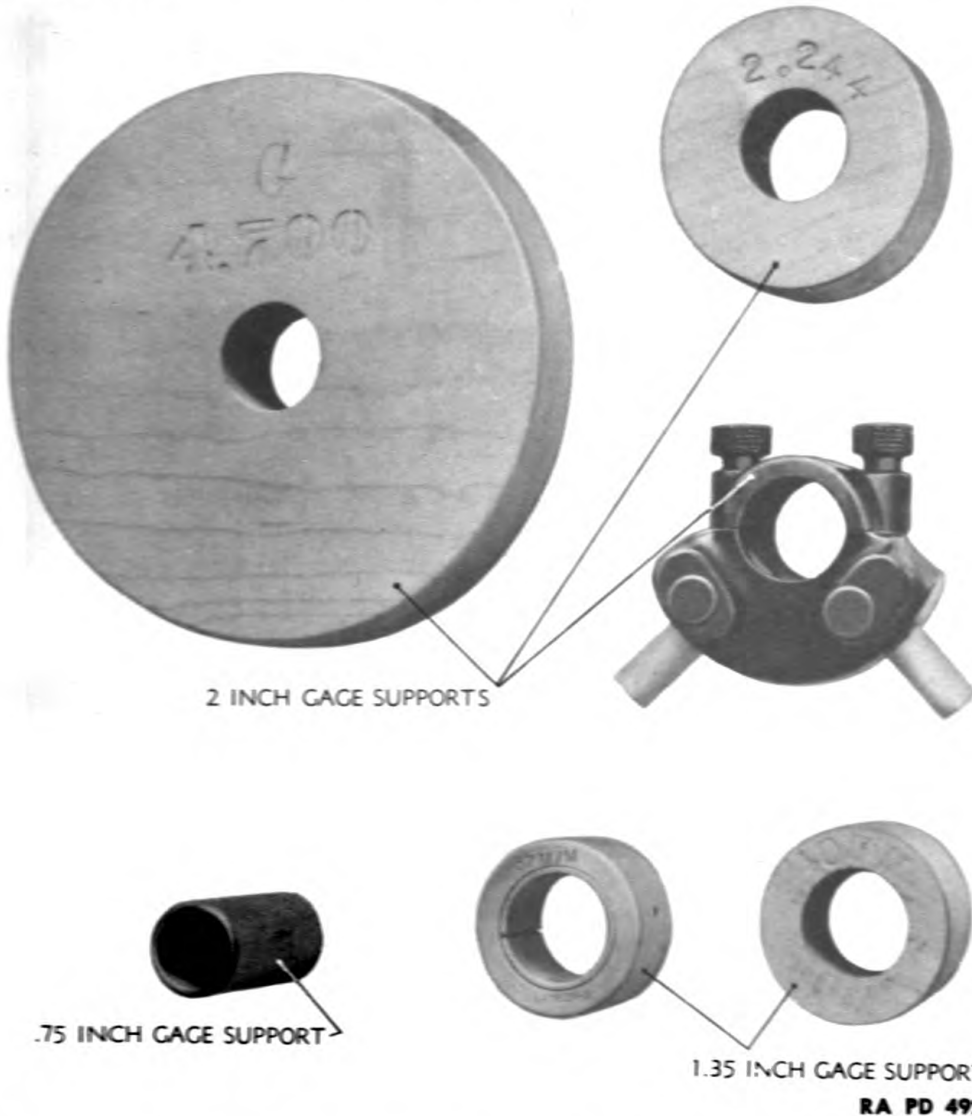


Figure 43A—Gage Supports for 0.75-inch, 1.35-inch and 2-inch Star Gages, Complete

NOTE: Records of assignment data must be removed and destroyed prior to entering combat.

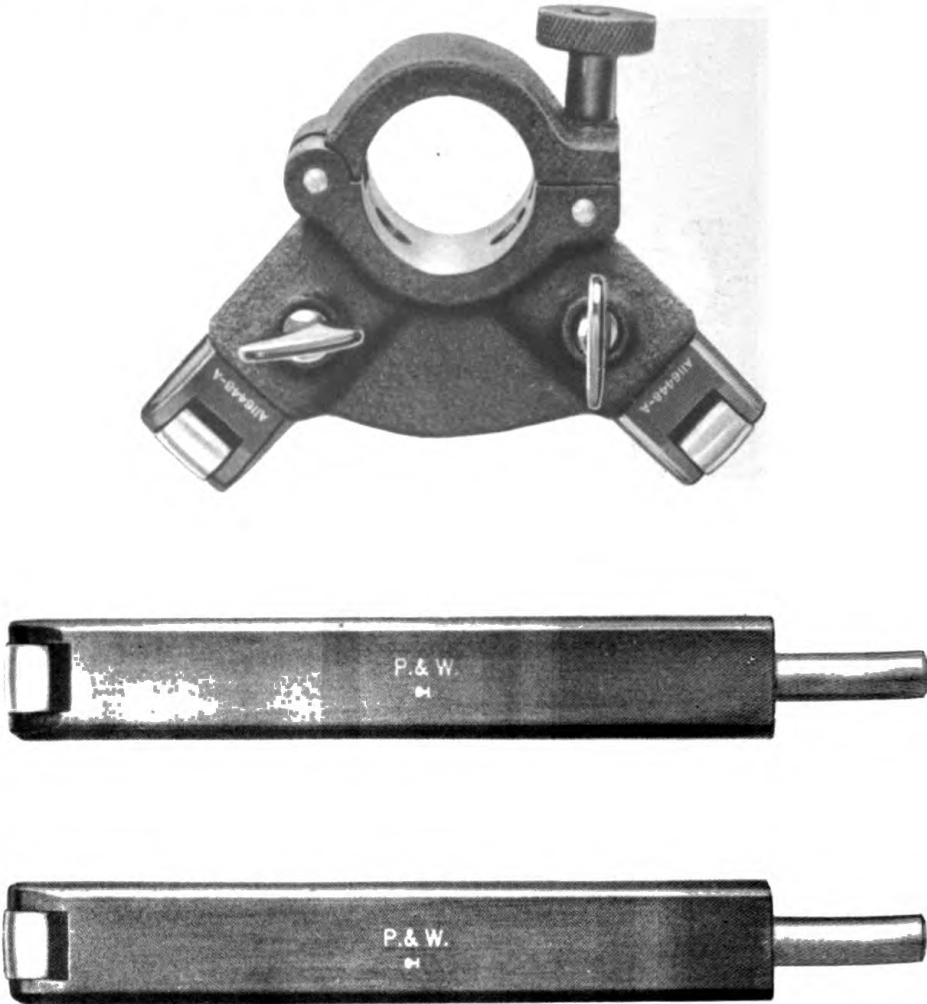
(2) The instructions at the front of the artillery gun book specify what data are to be entered in the book.

26. GAGE SUPPORTS (INTERIOR RESTS) (figs. 43A and 43B).

a. Gage supports are available for each cannon model. These devices serve to center the star gage within the bore and to prevent

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sagging of the staff while measurements are being taken. Wooden supports only are used with the 0.75-inch gage. Wooden supports and metal supports are available for the 1.35-inch and 2-inch gages. Metal supports only are used with the 5.75-inch gage. The supports are assembled over the staves at approximately 4-foot intervals. If metal gage supports are



RA PD 49220

Figure 43B—Metal Gage Support for 5.75-inch Star Gage with Extra Roller Legs

used, they are installed as needed and removed as they leave the cannon to prevent strain on the gage staves. (See also par. 12 d.)

27. GAGE STOPS (fig. 44).

a. These devices are occasionally used as an aid in reading the position of the measuring points in the cannon. The gage stop is held against the muzzle of the cannon being star-gaged and serves as an

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index to the scale graduations on the gage staff, showing the distance that the head with its measuring points has traveled from the gage stop.

28. CENTERING DEVICES (BREECH RESTS) (fig. 45).

a. These devices serve to hold the star gage in the center of the chamber or bore of the cannon. They are provided with wooden pins

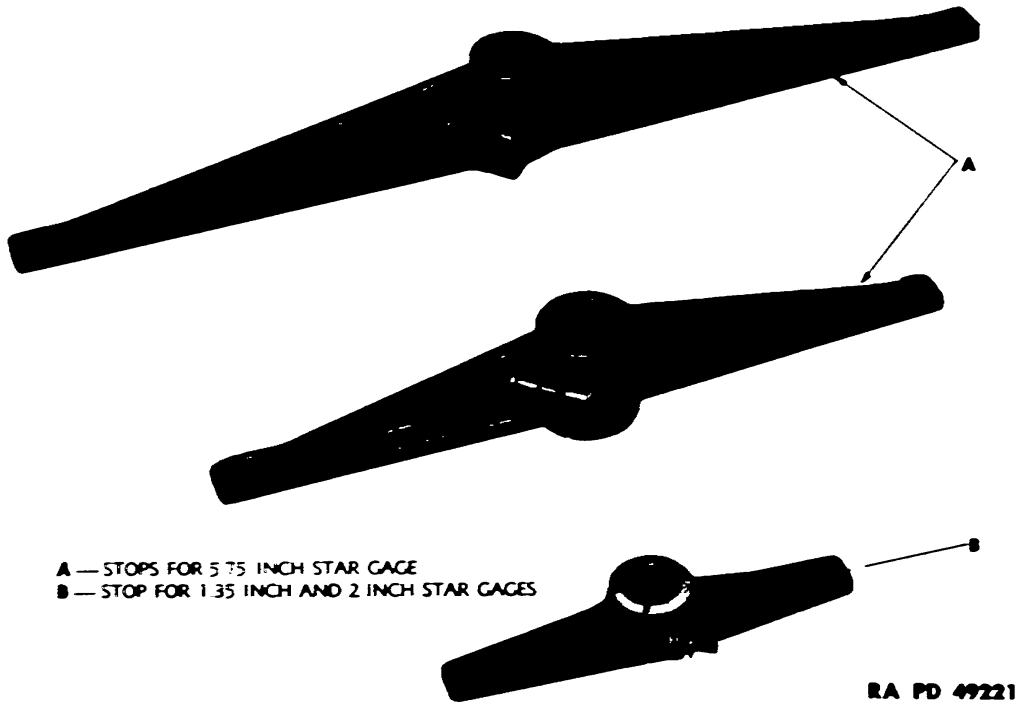


Figure 44—Gage Stops for 1.35-inch, 2-inch and 5.75-inch Star Gages

or rollers on which the star gage rides. The arms of the centering devices are graduated to facilitate setting the binding jaws to the diameter of the breech recess. (See NOTE in par. 20 b (6).)

29. RIFLING GUIDES (figs. 46 and 37).

a. These guides are provided to retain the measuring points of the star gage on the lands, or in the grooves, of the cannon being measured. Two types of rifling guide are available for each cannon model—one for use when gaging the lands and the other when gaging the grooves. In practice, a rifling guide generally is used only when gaging the lands.

30. SIZE RINGS (figs. 47 and 36).

a. These rings are made of heat-treated steel plate. They have a finished bore equal to that of the cannon for which they are designed

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Figure 45—Centering Device for 5.75-inch Star Gage

and are so stamped. Size rings are used when adjusting the vernier zero to the interior diameter (bore or chamber) to be star-gaged.

31. SIZE-RING SPIDERS (figs. 48 and 36).

a. The size-ring spiders are devices for holding the size rings rigidly in position when setting the measuring points at the zero vernier reading.

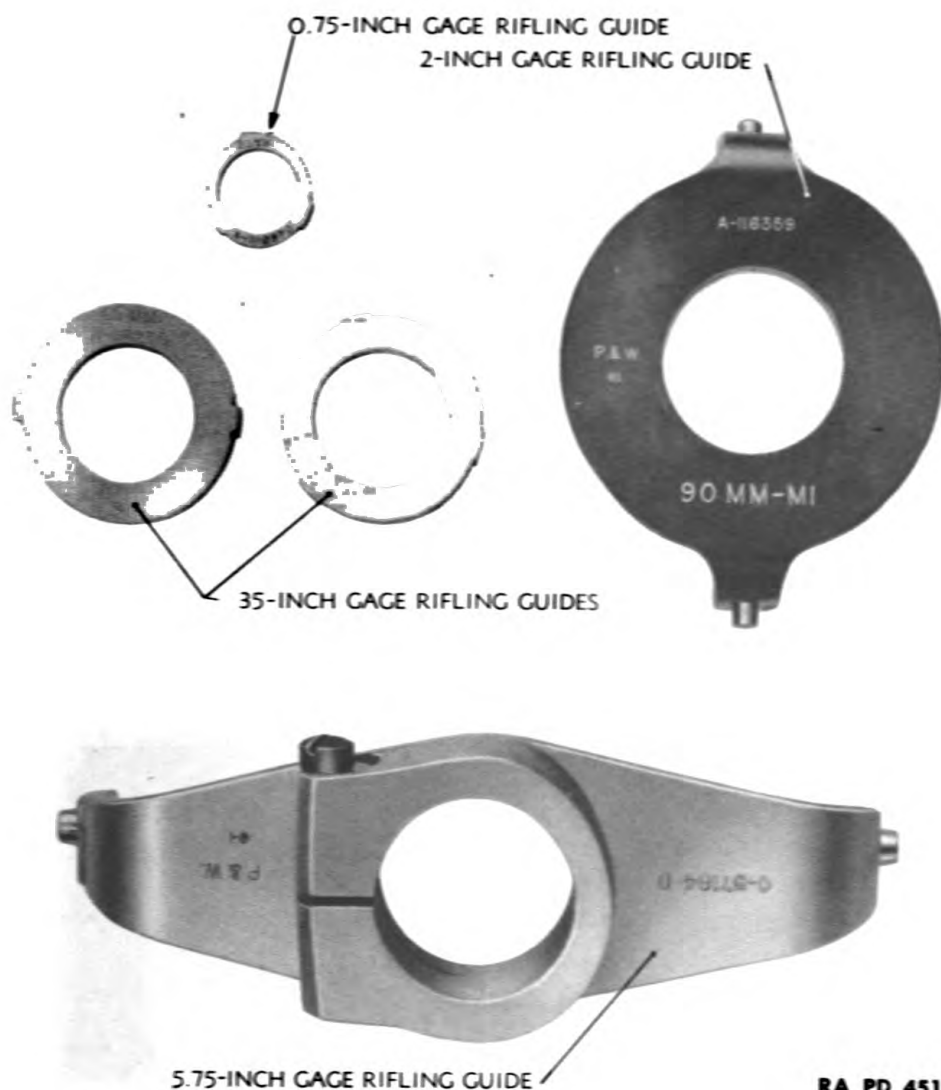
32. EXTERIOR RESTS (STANDS) (figs. 49 and 41B).

a. Exterior rests are provided to support the star gage in a horizontal position and to prevent sag when the gage is withdrawn from the cannon. The rests are adjustable in height. An iron rest and a wooden rest are shown in figure 49.

33. SPACING WASHERS (fig. 50).

a. The steel washers are hardened and ground to various thicknesses ranging from 0.01- to 0.15-inch, and are used to increase the range of the radial diameters of the measuring points.

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RA PD 45113

Figure 46—Rifling Guides for 0.75-inch, 1.35-inch, 2-inch and 5.75-inch Star Gages

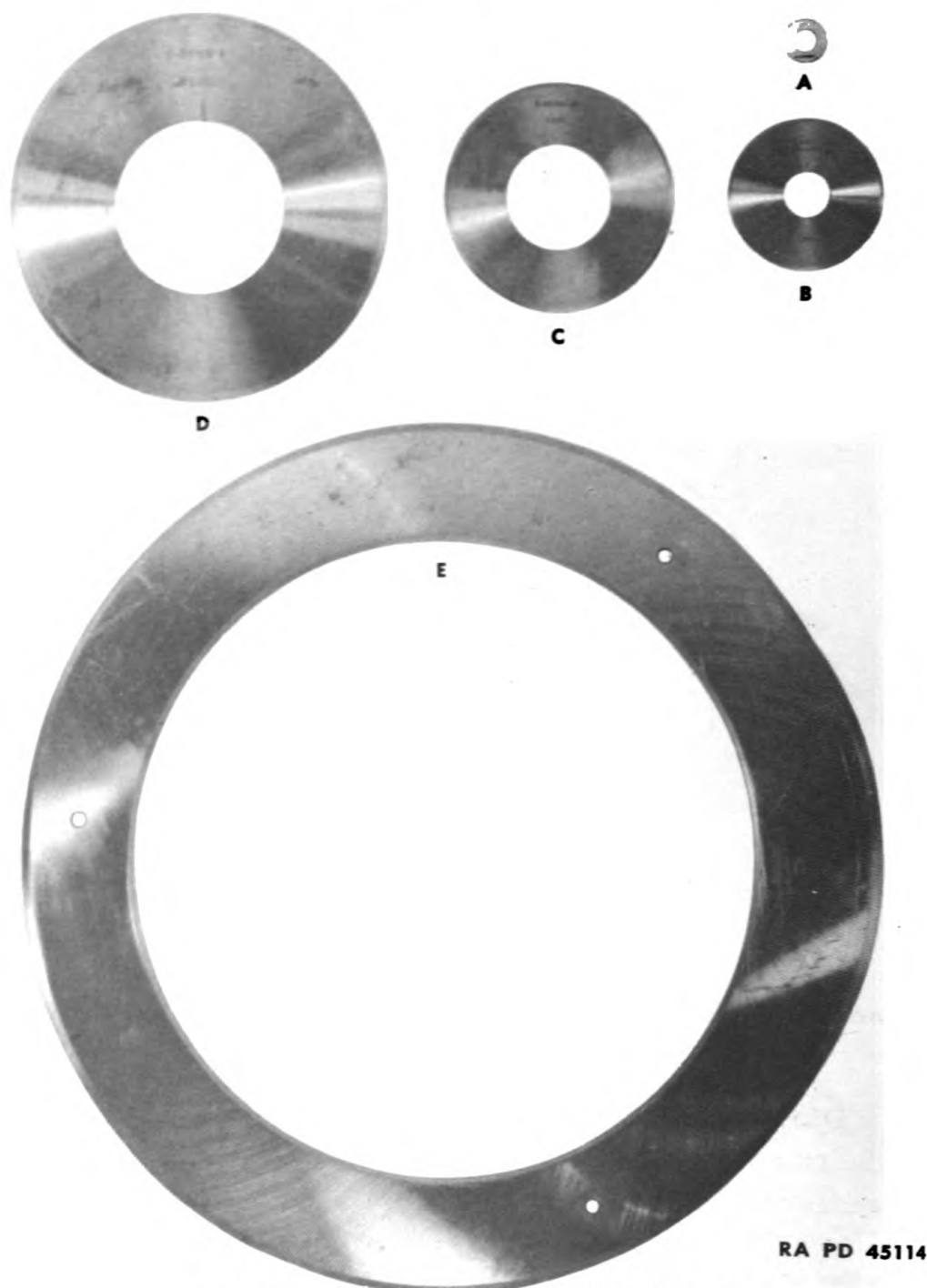
34. DISTANCE PIECES (EXTENSIONS) (fig. 50).

a. Distance pieces are cylindrical in form and are used to extend the range of the measuring points. One end is counterbored and threaded to receive the points. The other end has an external thread which mates with the interior thread of the measuring point carriers.

35. WRENCHES (fig. 51).

a. Special wrenches are provided in teat-end form and the conventional open-end types. Substitutes will not be used where wrenches are provided for use in a certain operation, as damage may result.

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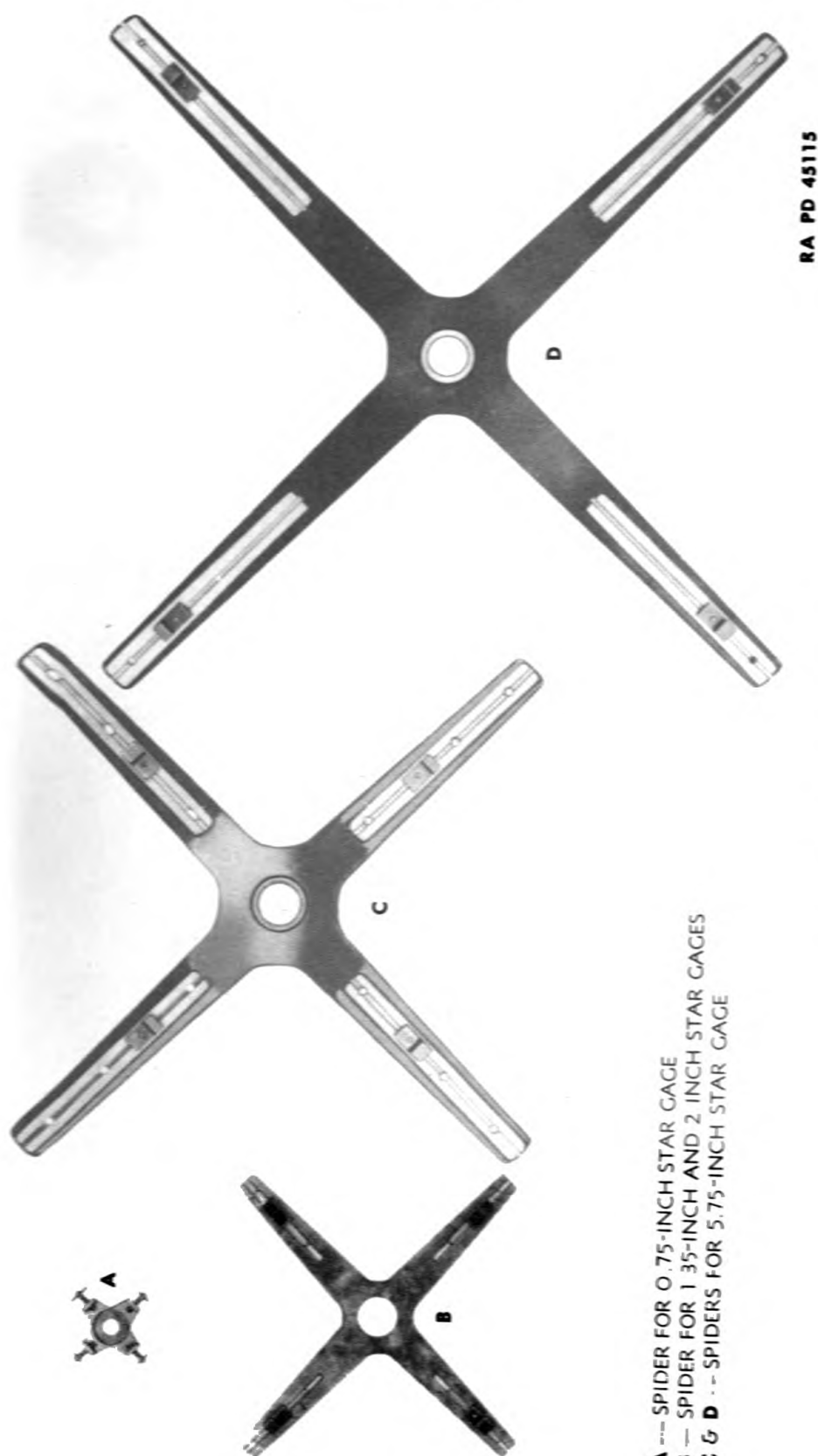


- A** — 0.817-INCH RING USED WITH 0.75-INCH STAR GAGE
B — 1.574-INCH RING USED WITH 1.35-INCH OR 2-INCH STAR GAGE
C — 3.677-INCH RING USED WITH 1.35 OR 2-INCH STAR GAGE
D — 6-INCH RING USED WITH 5.75-INCH STAR GAGE
E — 22-INCH RING USED WITH 5.75-INCH STAR GAGE

RA PD 45114

Figure 47—Size Rings

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RA PD 45115

Figure 48—Size-Ring Spiders

A --- SPIDER FOR 0.75-INCH STAR GAGE
B --- SPIDER FOR 1.35-INCH AND 2 INCH STAR GAGES
C & D --- SPIDERS FOR 5.75-INCH STAR GAGE

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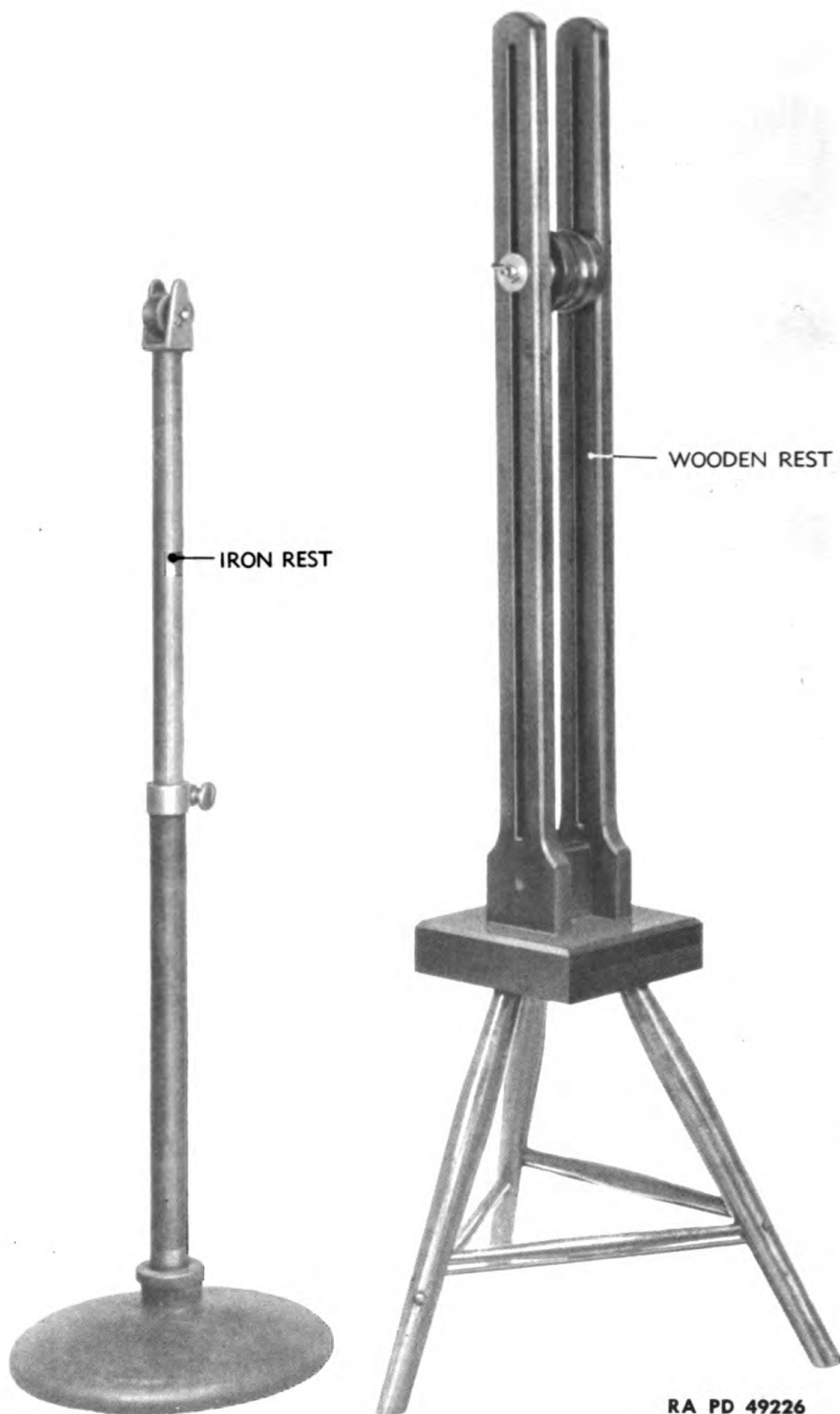


Figure 49—Exterior Rests

ACCESSORIES

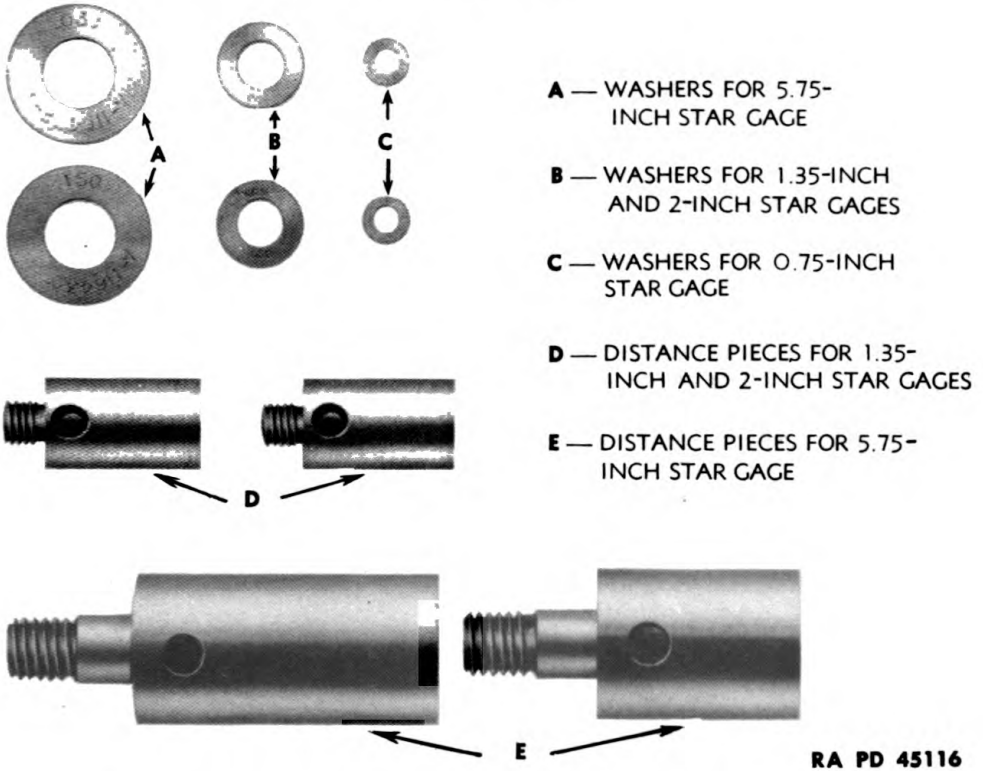
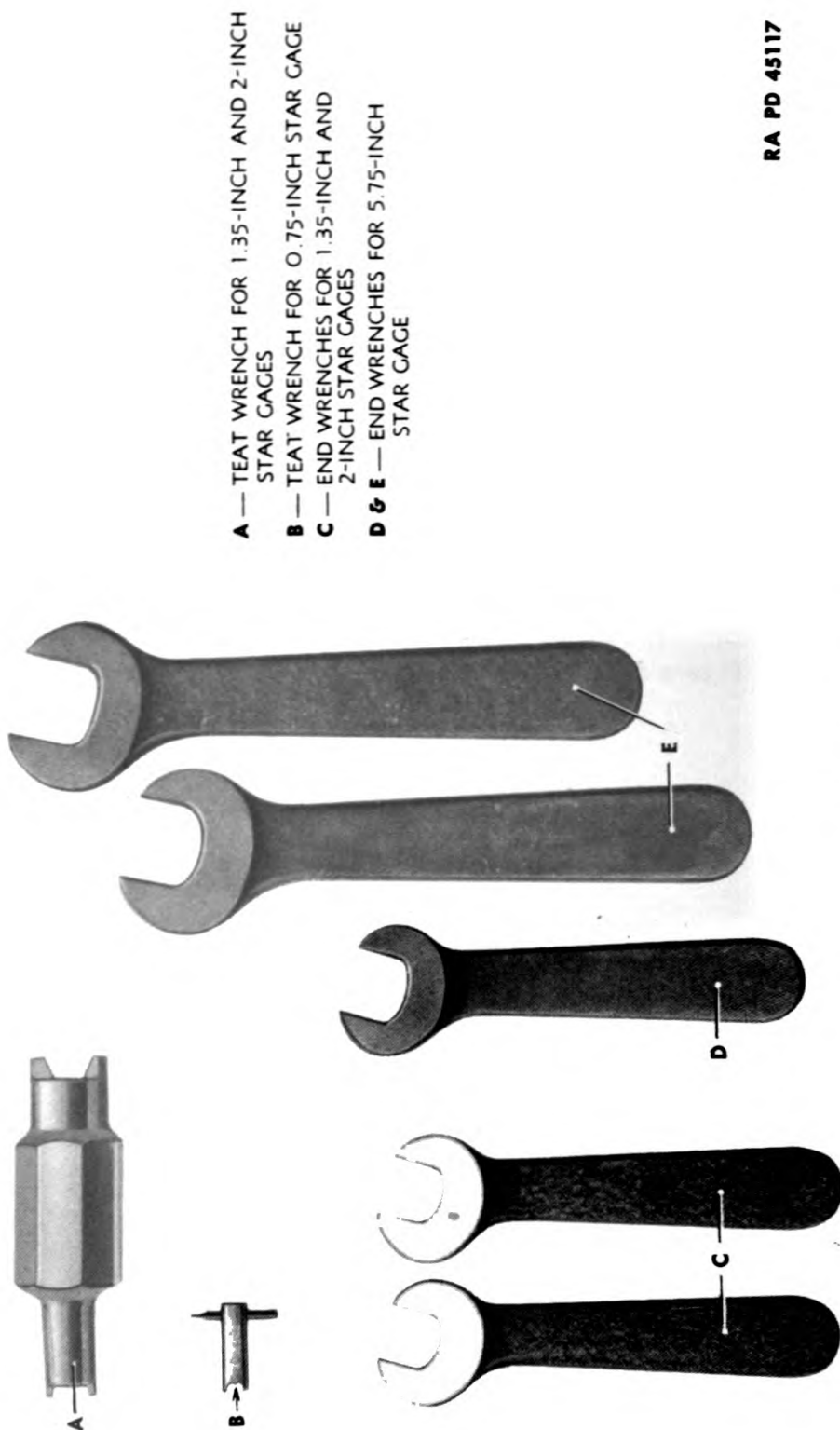


Figure 50—Spacing Washers and Distance Pieces

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- A** — TEAT WRENCH FOR 1.35-INCH AND 2-INCH STAR GAGES
- B** — TEAT WRENCH FOR 0.75-INCH STAR GAGE
- C** — END WRENCHES FOR 1.35-INCH AND 2-INCH STAR GAGES
- D & E** — END WRENCHES FOR 5.75-INCH STAR GAGE

RA PD 45117

Figure 51—Wrenches

Section VII

CARE AND PRESERVATION

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36. GENERAL.

a. The accuracy life of a star gage depends upon the way the instrument is handled, lubricated and packed in its chest. The parts of the instrument should not be allowed to strike or rub against each other. Care should be exercised in making up and dismantling the star gage to prevent injury by striking it against the gun or carriage or by permitting it to sag. All exterior rests will be clamped firmly at the proper height before the gage is placed on them so that none may drop, thereby permitting the star gage to fall.

b. Only a moderate pressure should be applied during the attachment of the staves or the lever handle in making up the gage. All threads should be assembled with a light touch. No attempt should be made to force a line-up of the scale graduations on two tubes.

c. If the star gage is to be used daily, for several days, it is not necessary to dismantle the gage after each star-gaging operation provided a suitable fixture is available for supporting the assembled gage as a unit.

d. If the star gage is used infrequently—once in three months or so—it should be dismantled after the star-gaging operations are completed and the subassemblies and accessories should be lubricated as described in the following paragraphs.

37. HEAD TUBE WITH WEDGE AND WEDGE OPERATING ROD.

a. **0.75-inch, 1.35-inch and 2-inch Star Gages.** Remove the head coupling (1.35-inch and 2-inch star gages or the lock nut 0.75-inch star gage). Remove the operating rod collar. Withdraw the spider cap, gage head, wedge and wedge operating rod as a unit. Wipe the wedge operating rod with a clean cloth, saturated with OIL, clock, or OIL, lubricating, preservative, light. Pour a small quantity (one-half ounce or so) of OIL, clock, or OIL, lubricating, preservative, light, into the

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hole in the spider cap and move the operating rod back and forth a few times, taking care not to withdraw the wedge from the head completely. Reassemble the head tube with wedge and wedge operating rod. Wipe the exterior surfaces of the head and head tube with a cloth, saturated with OIL, lubricating, preservative, light. Install the head tube with wedge and wedge operating rod in its proper place in the star-gage chest.

NOTE: 1st—If any oil is put on the measuring points, it will be necessary to remove the oil when the gage is to be used, to prevent erratic readings. 2nd—If a measuring point is bent or burred or if a point end is worn, the set of points will be returned to Watervliet Arsenal for replacement.

b. 5.75-inch Star Gage. Lock the locking pin in the head coupling in the extended position and unscrew and back off the head coupling. Remove the operating rod collar. Withdraw the outer bearing, head, wedge and wedge operating rod as a unit. Wipe the wedge operating rod with a cloth, saturated with OIL, clock, or OIL, lubricating, preservative, light. Pour a small quantity of oil into the outer bearing (through the venthole) and move the wedge operating rod back and forth a few times. Reassemble the head tube with wedge and wedge operating rod. Wipe the exterior surfaces of the head and head tube with a cloth, saturated with OIL, lubricating, preservative, light. Install the head tube with wedge and wedge operating rod in its proper place in the star-gage chest.

CAUTION: Make sure that the venthole is not plugged when storing the head tube, with wedge and wedge operating rod in the gage chest.

38. EXTENSION STAFF ASSEMBLY.

a. Wipe the exterior surfaces of the tube and bushing and the exposed portion of the wedge operating rod with a cloth, saturated with OIL, lubricating, preservative, light. Install the extension staff assembly in its proper place in the gage chest.

39. HANDLE, WITH SLIDE, ASSEMBLY.

a. Wipe the exposed portion of the vernier sleeve with a cloth, saturated with OIL, clock, or OIL, lubricating, preservative, light, and move the handle back and forth a few times. Wipe all the exterior metal surfaces with a cloth, saturated with OIL, lubricating, preservative, light. Install the handle, with slide, assembly in its proper place in the gage chest.

CARE AND PRESERVATION

40. ACCESSORIES.

a. Wipe the accessories—size rings, spiders, rifling guides, gage supports, gage stops, etc.—with a cloth saturated with OIL, lubricating, preservative, light, and install the accessories in their proper places in the gage chest.

41. STORAGE.

a. If the gage is to be stored for an indefinite period, disassemble the head tube with wedge and wedge operating rod, the extension staff assembly and the handle, with slide, assembly completely, as described in section III. Clean the parts with SOLVENT, dry-cleaning, and dry thoroughly. Apply COMPOUND, rust preventive, light. Reassemble the assemblies. Clean the extra measuring points and the accessories—size rings, spiders, rifling guides, etc.—with SOLVENT, dry-cleaning, dry thoroughly and apply COMPOUND, rust preventive, light.

b. Rust and discoloration are often found on instruments where the felt or velvet linings of supporting fixtures contact them. This may be due to the felt or velvet being damp or absorbing the preservative from the metal, thus leaving it unprotected. Therefore, points of contact between the instrument and velvet linings should be separated by several layers of waxed or oilproof paper to avoid absorption by the lining of the preservative and to prevent transmission of moisture from the lining to the metal.

c. When accessories additional to those for which the chest was designed are to be placed in the chest, provide fixtures to retain them in place, thereby avoiding damage when the chest is handled.

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Section VIII

DIAL INDICATOR GAGES

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42. GENERAL.

a. The dial indicator gages described in this section are spring-actuated devices for measuring variations in bore diameters. At present, separate dial indicator gages are used for each cannon caliber. It is proposed, however, to use 2-point heads and to provide extra measuring points and intermediate or extension tubes so that one gage can be used for several calibers. Specifically, one gage for 37-mm, 40-mm and 57-mm caliber cannon; another gage for 75-mm, 3-inch, 90-mm, 105-mm, 4.5-inch and 4.7-inch caliber cannon; and a third gage for 155-mm, 8-inch and 240-mm caliber cannon.

b. All of the dial indicator gages for star-gaging cannon of 37-mm caliber, and higher, are similar in construction and operation. They comprise a head tube, indicator housing tube and indicator housing assembly (fig. 52). The dial indicator gage for 20-mm cannon differs from that shown in figure 52 in having a rotating member (adapter) installed between the indicator housing tube (extension tube) and the indicator housing assembly (fig. 62).

c. Dial indicator star gages, like the lever-type star gages, are precision instruments which must be handled carefully.

43. FUNCTIONING.

a. A simplified section of a dial indicator gage with 3-point head is shown in figure 53. The construction of the dial indicator gage differs

DIAL INDICATOR GAGES

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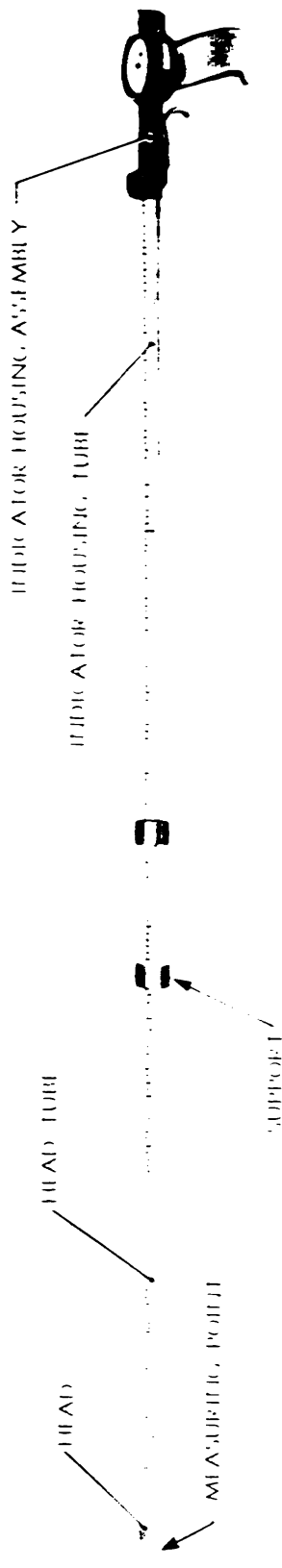
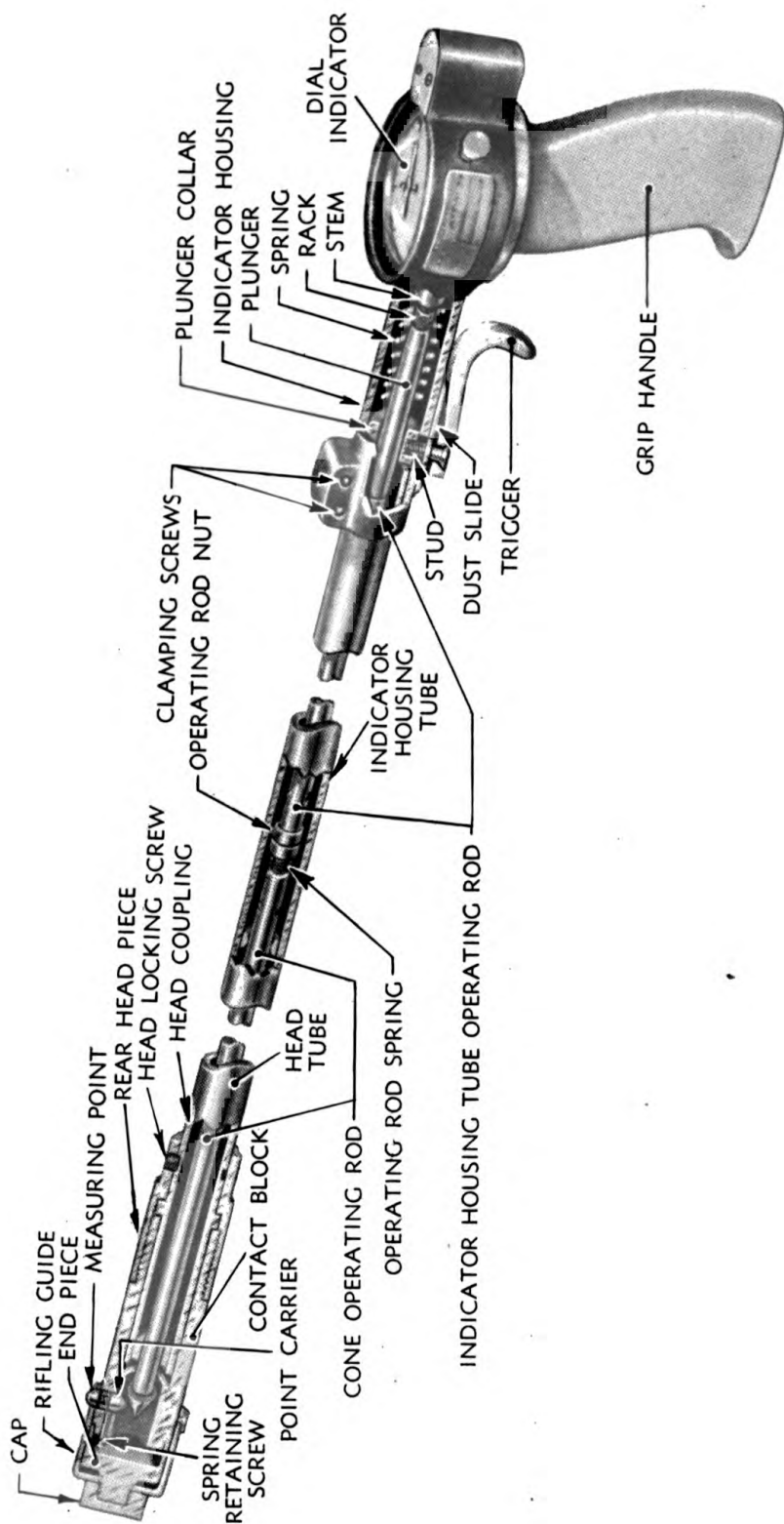


Figure 52—Exterior View of Dial Indicator Gage (3-point Cylinder Gage for 37-mm Caliber Guns)

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Figure 53—Schematic Section of Dial Indicator Gage

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from that of the lever-type gage chiefly in the dial indicator, the trigger operating mechanism and the thrust action between the rear end of one operating rod and the forward end of an adjacent operating rod. The head of the dial indicator gage, like that of the lever-type gage, has measuring points which ride along a conical wedge installed at the forward end of the cone operating rod.

b. The dial hand is actuated by gears engaging with a rack. The forward end of the rack butts against the rear end of a plunger attached to the trigger rigidly by a stud. A spring is assembled around the rear end of the plunger. The forward end of the plunger butts against the rear end of the indicator housing tube operating rod. The forward end of the indicator housing tube operating rod, in turn, butts against the rear end of the cone operating rod.

c. When the gage is adjusted to "zero," corresponding to the caliber of the cannon to be gaged, the plunger spring is placed under an initial tension. Thereafter, pulling the trigger rearward forces the plunger rearward and further compresses the spring. When the trigger is released, the compressed spring expands and pushes the plunger forward. This in turn causes the operating rod and cone to move forward and the measuring points to move outwardly.

d. If the bore diameter at the position being measured is exactly the same as the diameter for which the gage was set to zero, the dial indicator hand will return to zero when the trigger is released. If the gun bore is larger than the diameter for which the gage was set to zero, the dial indicator will show a positive reading when the trigger is released, and if it is smaller, the dial indicator will show a negative reading.

44. SHIPMENT.

a. Dial indicator star gages are packed in chests, one gage complete with accessories for one gun model per chest (fig. 54). As in the case of lever-type gages, size, model and serial number of the cannon to be star-gaged should be stated when ordering a gage.

45. DESCRIPTION OF GROUPS.

a. Head Tube.

(1) The head tube is made of steel tubing and is graduated in fourths, with the inches numbered (fig. 55). Cylindrical wooden supports (1 inch long) are held in place on the head tube by set screws. The head tube houses the cone operating rod.

(2) The cone operating rod is a round steel rod, $\frac{3}{16}$ inch in diameter. The operating rod is provided with a cone operating rod spring (about $1\frac{1}{2}$ inches long) which is installed between the operating rod nut at the

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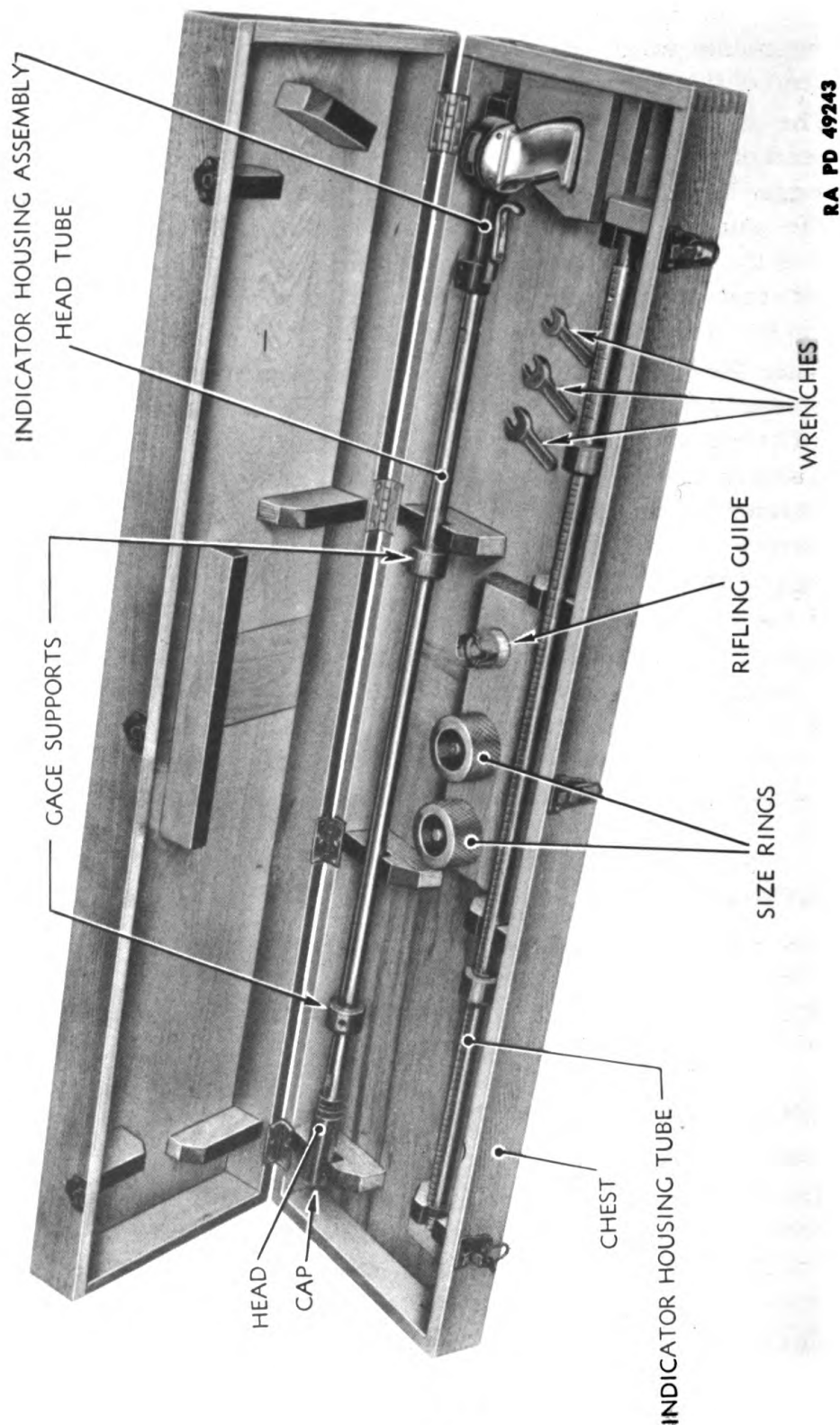
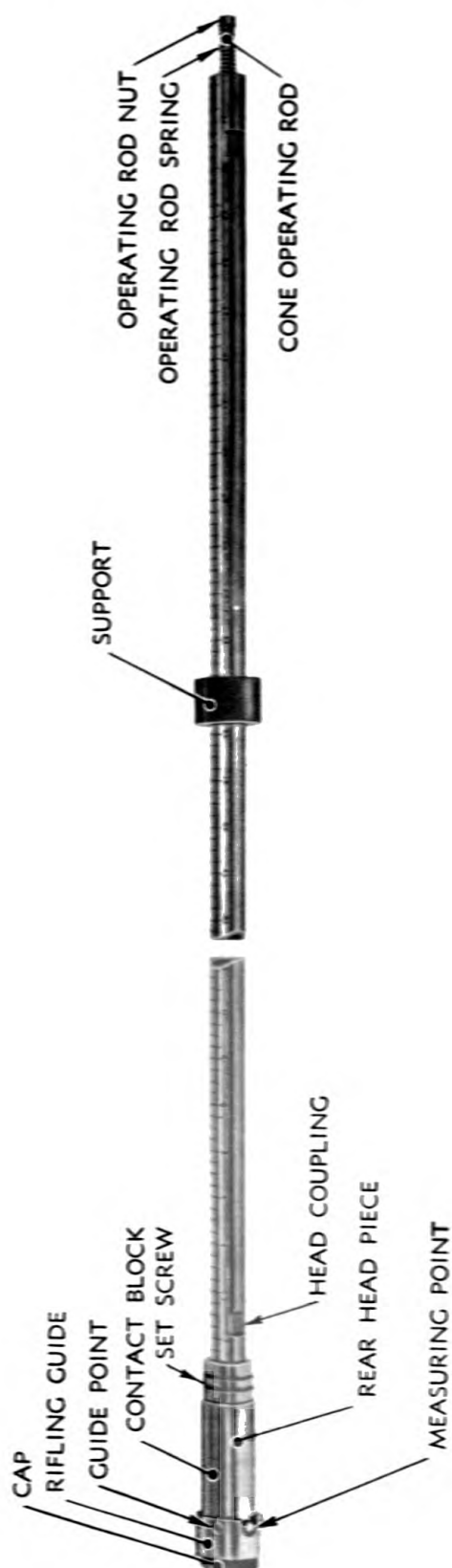


Figure 54.—Dial Indicator Star Gage and Accessories in Chest (3-point Cylinder Gage for 37-mm Caliber Guns)

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Figure 55—Head Tube (3-point Cylinder Gage for 37-mm Caliber Guns)

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rear end of the rod and a metal support securely mounted in the interior of the head tube. The forward end of the operating rod carries a conical wedge on which the measuring points ride.

(3) The head is composed of two cylindrical pieces which are screwed together. The forward headpiece (contact block) has three recesses, equally spaced, for the measuring point carriers and three exterior "flats" for the legs of the rifling guide. The rear headpiece is secured to a head coupling mounted at the forward end of the head tube by a set screw.

(4) An end piece which is secured to the forward end of the contact block by three screws and a rifling guide cap are provided to protect the conical wedge.

(5) The outer ends of the measuring point carriers are bored and tapped to receive the measuring points. The carriers are also bored and tapped at right angles to the measuring points for a spring retaining screw (fig. 58). Small compression springs (about $\frac{1}{8}$ inch long) are connected to the screws and serve to "steady" the point carriers.

b. Indicator Housing Tube. The indicator housing tube is made of steel tubing and is graduated in fourths, with the inches numbered (fig. 56). Wooden supports are held in place on the indicator housing tube by set screws. The indicator housing tube contains a round, steel operating rod, $\frac{3}{16}$ inch in diameter, which slides freely in it. The forward end of the indicator housing tube operating rod has a short ($\frac{1}{4}$ -inch long) cylindrical end piece with rounded end surface tightly installed on it. When the gage is assembled, the rear (flat) end of the cone operating rod bears against the forward (rounded) end of the indicator housing tube operating rod.

c. Indicator Housing Assembly. The indicator housing assembly includes a dial indicator, plunger, trigger and grip handle (figs. 57 and 60).

(1) The dial indicator is graduated in units of 0.0005 inch with the 0.005-inch graduations numbered. The range of the indicator shown in figure 57 is approximately $2\frac{2}{3}$ complete revolutions of the dial hand or 0.08 inch.

(2) The rear portion of the indicator housing plunger is surrounded by a spring (fig. 61). When the gage is assembled, the rear end of the plunger bears against the dial indicator rack and the forward end of the plunger bears against the indicator housing tube operating rod. Translation of the plunger is produced by pressing or releasing the trigger.

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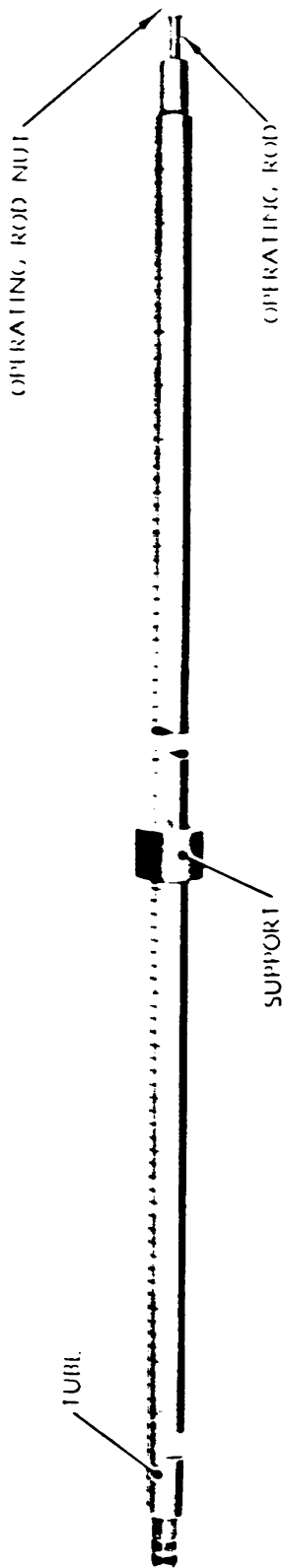
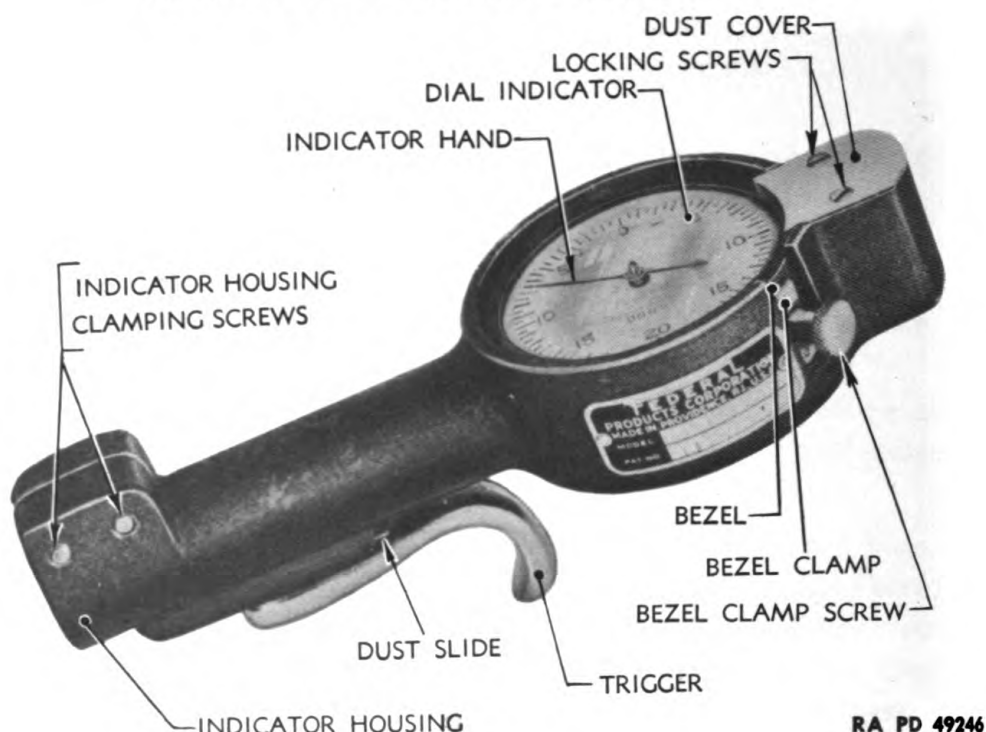


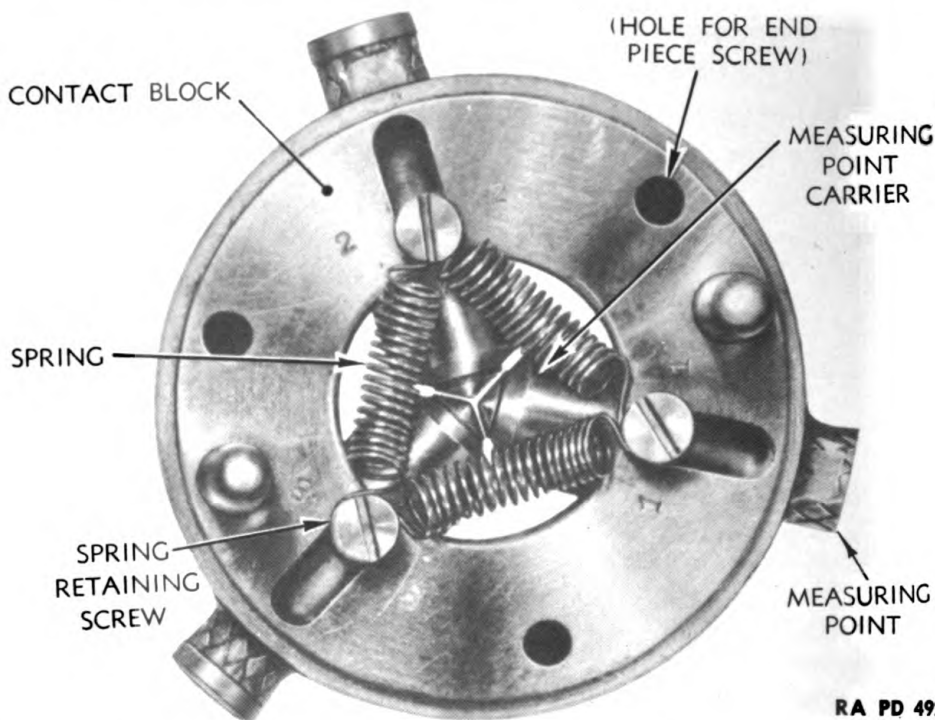
Figure 56—Indicator Housing Tube

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Figure 57—Indicator Housing Assembly with Grip Handle Removed



RA PD 49247

**Figure 58—End View of Contact Block with Cap and End Piece Removed
(3-point Cylinder Gage for 37-mm Guns)**

DIAL INDICATOR GAGES**46. DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES.**

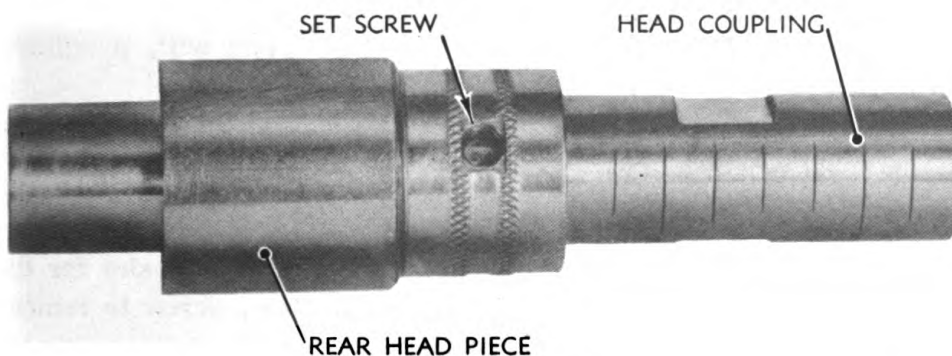
a. **General.** The dial indicator gage units shipped in the gage chest ordinarily will be disassembled only for the following reasons: (1) to prepare the gage for indefinite storage or (2) to remove grease or COMPOUND, rust preventive, used in shipping or storing the gage. (Compare par. 6 and par. 11 a.)

b. **Head Tube** (figs. 55 and 58)

- (1) Unscrew and remove rifling guide cap. Lift off the rifling guide.
- (2) Unscrew and remove the contact block.
- (3) Using a suitable screwdriver, unscrew and remove the three screws securing the end piece to the contact block. Lift off the end piece.
- (4) Loosen one spring retaining screw and remove the measuring point carrier and measuring point as a unit. Unscrew the measuring point from the point carrier. Remove the other two measuring point carriers and measuring points in the same manner.

CAUTION: Replace the previously removed measuring point carrier and measuring point *before* removing the next carrier and point.

- (5) Unscrew and remove the operating rod nut at the rear end of the cone operating rod. Remove the operating rod spring.



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Figure 59—Head Coupling and Rear Headpiece

- (6) Withdraw the cone operating rod from the forward end of the tube.

CAUTION: Do not disassemble the conical wedge and cone operating rod.

- (7) Using two end wrenches (fig. 54), unscrew the head coupling from the head tube. Remove the head coupling and rear headpiece as a unit from the head tube (fig. 59).

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(8) Unscrew the set screw in the rear headpiece with a suitable Allen wrench and remove the rear headpiece from the head coupling.

(9) To assemble the head tube, reverse steps (8) through (5) and (3) through (1).

CAUTION: If the gage is to be used immediately for star-gaging operations, clean the measuring points and the point carriers with SOLVENT, dry-cleaning, to remove all traces of grease. Do *not* apply any oil when assembling the points and carriers.

c. Indicator Housing Tube and Indicator Housing Assembly.

(1) Loosen two indicator housing clamping screws with a suitable Allen wrench and remove indicator housing assembly from indicator housing tube.

(2) To assemble the indicator housing tube and indicator housing assembly reverse step (1).

d. Indicator Housing Tube.

(1) Unscrew and remove operating rod nut (fig. 56). Remove operating rod spring, if there is one assembled to the rod. Withdraw the operating rod from the tube.

(2) To assemble, reverse step (1).

e. Indicator Housing Assembly.

(1) Unscrew the four grip handle locking screws with a suitable screwdriver and remove the grip handle.

(2) Unscrew and remove the two dust cover locking screws with a suitable screwdriver and remove the dust cover.

(3) Loosen the bezel clamp screw.

NOTE: If the dial indicator housing does not have a slot for the bezel clamp, it is necessary to remove the bezel clamp screw to remove the dial indicator.

(4) Unscrew and remove the two indicator locking screws on the bottom flat surface of the indicator housing (under the grip handle).

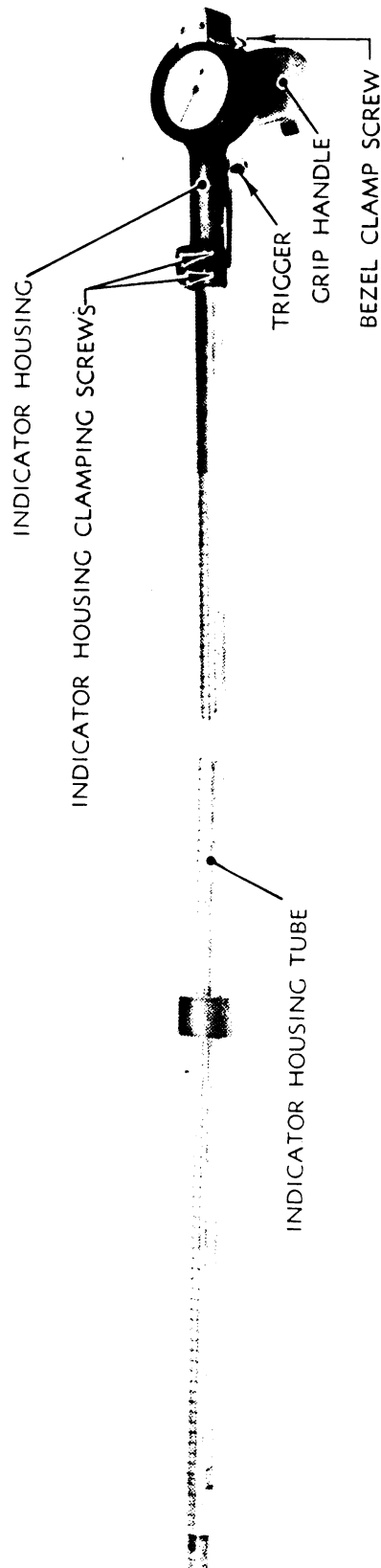
(5) Lift out the dial indicator.

CAUTION: The dial indicator is a clock- or watch-type mechanism which is adjusted at the manufacturing plant with special tools. No attempt should be made to disassemble this mechanism.

(6) Unscrew and remove the trigger locking screw and remove the trigger from the indicator housing.

(7) Holding one hand over the hole at the forward end of the indicator housing, unscrew and remove the plunger stud with a pair of pliers or a small open-end wrench. Remove the dust slide.

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Figure 60—Indicator Housing Tube and Indicator Housing Assembly

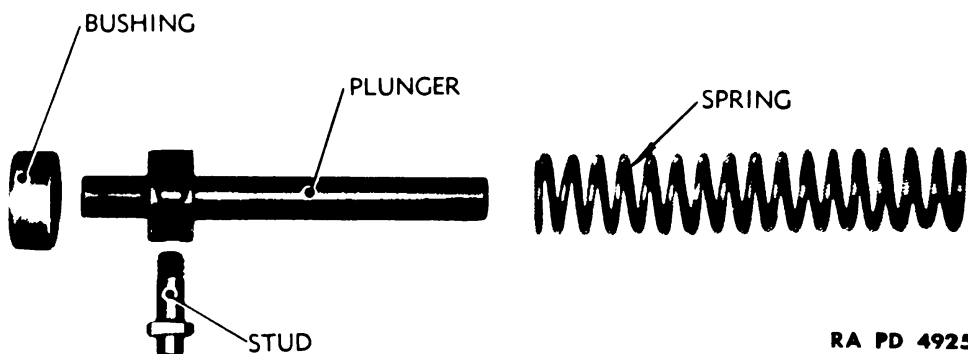
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CAUTION: When the plunger stud is removed, the plunger spring may force the plunger out of the hole at the forward end of the indicator housing.

(8) If the plunger spring and plunger did not come out in step (7), remove these parts now. Do not remove the plunger collar from the plunger (fig. 61).

NOTE: Some models are provided with a plunger bushing at the forward end of the indicator housing which must be removed before the plunger spring and plunger can be removed. If this bushing is stuck, hammer the end of the housing to free it.

(9) To assemble the indicator housing assembly, reverse steps (8) through (1). It will be necessary to line up accurately the stud hole in the indicator housing with the proper hole in the plunger collar.



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Figure 61—Indicator Housing Plunger and Spring

47. ASSEMBLING THE DIAL INDICATOR GAGE FOR OPERATION.

a. Dial indicator gages for star-gaging cannon of 37-mm caliber and higher are made up for use by assembling the head tube to the indicator housing tube and indicator housing assembly.

(1) Remove the head tube from the gage chest. Move the cone operating rod back and forth to check that the measuring points move in and out smoothly.

(2) Remove the indicator housing tube and indicator housing assembly as a unit from the gage chest. Press the trigger and release it a few times and observe whether the indicator hand moves freely. If it does, proceed with step (5) below. If the indicator hand sticks, proceed as follows:

(3) Remove the indicator housing assembly from the indicator housing tube as described in paragraph 46 c.

(4) Remove the dial indicator from the indicator housing (par.

DIAL INDICATOR GAGES

46 e, steps (1) through (5)). Operate the trigger and observe whether the indicator housing plunger moves freely in the housing.

(a) If the plunger does not move freely, assemble the plunger in the housing properly. Reassemble the indicator housing assembly. Install it on the indicator housing tube, and proceed with step (5) below.

(b) If the plunger does move freely, the cause of the sticking is in the dial indicator. Clean the forward contact point of the knurled indicator rack with a clean cloth, dampened with SOLVENT, dry-cleaning. Pour a drop or two of the solvent between the rack and stem and move the rack back and forth a few times. (Do *not* apply any oil to the rack.) Reassemble the indicator housing assembly. Operate the trigger and observe the motion of the indicator hand. If the hand functions satisfactorily, assemble the indicator housing assembly to the indicator housing tube and proceed with step (5) below. If the indicator hand still sticks, the indicator must be returned to the manufacturer for repair.

(5) Adjust two exterior rests (fig. 49) to the same height (50 inches or so) and place the head tube on one rest and the indicator housing tube and indicator housing assembly on the other. Slide the forward end of the indicator housing tube over the threaded end of the head tube and screw the two tubes "home." Use only a moderate pressure.

CAUTION: Take care that the tubes do not slip off the rests during make-up.

b. Making the "Zero" Adjustment.

(1) Loosen the two indicator housing clamping screws with a suitable Allen wrench.

(2) Install the proper size ring for the lands.

(3) Carefully push the indicator housing assembly forward on the indicator housing tube as far as it will go without forcing.

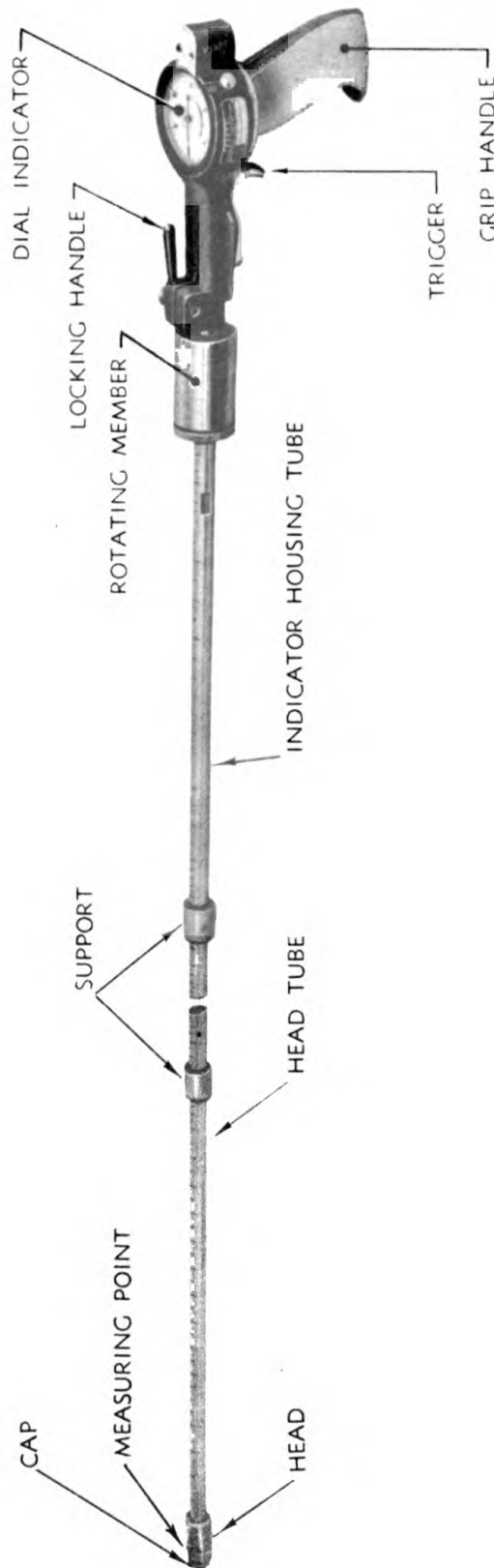
(4) Back up the indicator housing assembly until the indicator hand has rotated 1 to $1\frac{1}{2}$ complete revolutions. Tighten the indicator housing clamping screws.

(5) Loosen the bezel clamp screw and rotate the bezel until the zero graduation on the dial coincides with the indicator hand. Tighten the bezel clamp screw. The gage has now been adjusted so that it will read "0" when installed in a bore exactly equal to that of the size ring.

(6) Remove the size ring from the gage head.

NOTE: When the size ring is removed, the indicator hand will rotate to a reading determined by the tension on the plunger spring when the clamping screws were tightened in step (4).

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Figure 62—Exterior View of Dial Indicator Star Gage (3-point Cylinder Gage for 20-mm Guns)

DIAL INDICATOR GAGES

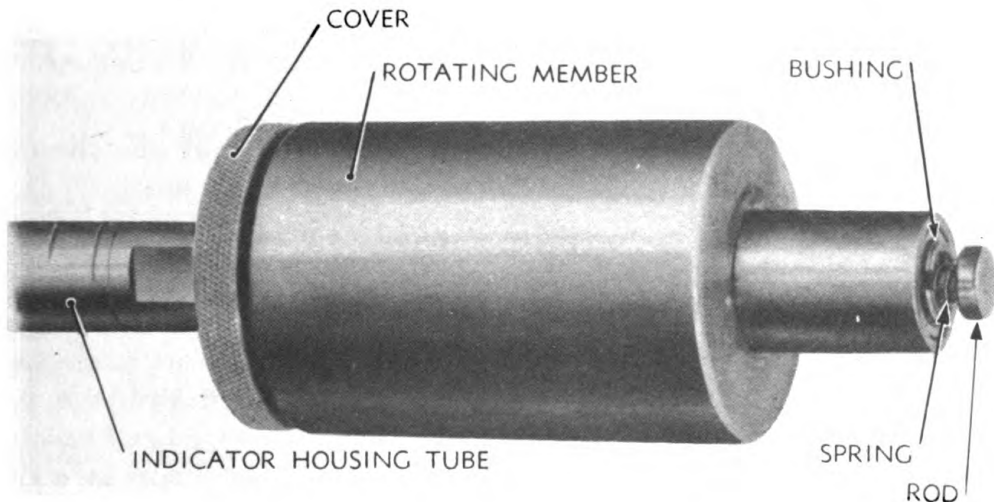
48. DIAL INDICATOR GAGE FOR 20-MM CANNON.

a. Description.

(1) The head is mounted on the head tube rigidly (fig. 62). The head tube, indicator housing tube and the operating rod rotate in the rotating member (adapter). In most of the gages, a locking screw is provided to lock the indicator housing tube and rotating member against rotation.

(2) The rotating member couples the indicator housing tube to the indicator housing assembly (fig. 63). A threaded tube at the forward end of the rotating member mates with the exterior thread at the rear end of the indicator housing tube. The rotating member tube houses the rear portion of the indicator housing tube operating rod. The rear end of the tube is mounted on ball bearings in the center of the rotating member. A knurled cover fits over the tube and protects the bearing races.

(3) The rear portion of the rotating member houses a short operating rod (about 4 inches in length). A short ($\frac{3}{8}$ -inch) threaded and slotted bushing is screwed into the rear end of the rotating member



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Figure 63—Rotating Member

and a small compression spring is installed between the bushing and the rear buttonhead of the rotating member operating rod. The tension of the rod spring is adjusted in the factory by screwing up, or unscrewing, the bushing. The setting of the bushing should not be altered. When the gage is assembled, the buttonhead on the rotating member operating rod bears against the forward end of the indicator housing plunger

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(4) The indicator housing assembly is similar to that described in paragraph 45 c except that it has a locking handle instead of clamping screws.

b. Assembling the Gage for Operation. The gage is usually stored in the gage chest in two units: (1) the indicator housing tube, rotating member and indicator housing assembly; (2) the head tube. The gage is made up by sliding the forward end of the indicator housing tube over the threaded end of the head tube and screwing the two tubes "home."

c. Making the "Zero" Adjustment. The procedure is similar to that described in paragraph 47 b except that the indicator housing assembly is moved forward, and then rearward, on the rear part of the rotating member and locked in place with the locking handle.

49. STAR-GAGING A CANNON BORE WITH A DIAL INDICATOR GAGE.

a. General. The general instructions given in paragraph 17 b and c for lever-type star gages also apply for dial indicator star gages.

b. Star-gaging a Cannon Bore. As in the case of the lever-type star gages (par. 19 a), measurements are made from the muzzle end if possible.

(1) To prepare the gun for star-gaging, clean the bore and chamber thoroughly.

(2) Mount two exterior rests forward of the muzzle and in line with the axis of the bore (fig. 49). Place one rest 1 or 2 feet from the muzzle of the gun and the second about 5 feet from the first. Clamp the rests firmly at the same height as that of the cannon bore.

(3) Place the assembled star-gage head on the rests with the star-gage head near the muzzle. Check whether the star-gage head revolves freely. Check the dial indicator zero setting with the proper size ring.

(4) Install the proper rifling guide on the star-gage head.

NOTE: The rifling guide used for measurements of the lands has three contacts which straddle the lands.

(5) Holding the trigger pressed rearward, move the gage a short distance in the bore. Rotate the head and rifling guide so that the measuring points are in the center of the lands.

(6) Advance the gage in the bore to the distance shown on the record form for the first measurement (figs. 38 and 39). (The assistant will tell the operator when the scale graduation on the head tube corresponding to the position of the first measurement is in line with the muzzle face.) (Compare par. 19 a (7).)

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(7) Release the trigger with one hand while holding the gage steady with the other hand and observe the reading on the dial indicator. Press the trigger and release it again to get a check reading. Record the reading on the star-gage record form and proceed with step (8).

NOTE: When taking the second or check reading, it may be necessary to "settle" the gage by moving it up and down or back and forth slightly to see whether the dial indicator hand will come to rest at the same graduation as for the first reading. If the dial indicator readings are erratic, withdraw the gage from the gun bore and check the make-up of the gage as follows:

(a) Check that the measuring points are screwed up tightly.

(b) Check that the indicator housing clamping screws are screwed up tightly.

(c) Remove the dial indicator from its housing (par. 46 e) and check whether the forward contact point of the knurled indicator rack is screwed up tightly.

(d) Check whether the two indicator locking screws (under the trigger handle) are screwed up tightly.

(8) Holding the trigger pressed rearward, carefully guide the gage along the bore to the next measuring position shown on the record form and proceed as in step (7).

(9) Continue taking measurements along the bore until the gage head reaches the origin of rifling.

CAUTION: 1st—At no time will force be used to advance the gage through the bore. 2nd—The operator should take care that the gage head does not run off the rifling, because it may be difficult to work the gage head back on the rifling again.

(10) After measuring the diameter of the lands at the origin of rifling, back up the gage approximately to the next to the last position measured and again carry out a star-gaging measurement. Continue withdrawing the gage and taking measurements until the gage head is approximately at the first position measured.

(11) Withdraw the gage completely from the bore. Check the "Zero" adjustment with the size ring. If the dial indicator does not read "Zero" when the measuring points bear against the bore of the size ring, it will be necessary to repeat the entire set of measurements.

(12) If the diameter of the grooves is to be measured, carry out steps (4) through (11), taking care in step (5) to have the measuring points bear against the center of the grooves.

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
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a. At present, dial indicator gages are supplied only with size rings suitable for the grooves, lands and centering chamber. Instructions for star-gaging cannon powder chambers with a lever-type star gage are given in paragraph 20.

51. ACCESSORIES FOR DIAL INDICATOR STAR GAGES.

a. The accessories furnished with each dial indicator star gage at present are: Size rings, rifling guides (one for the lands and one for the grooves) and end wrenches (fig. 54).

52. CARE AND PRESERVATION.**a. General.**

(1) The general instructions given in paragraph 36 a for lever-type star gages apply also to dial indicator star gages.

(2) If the dial indicator star gage is to be used daily, for several days, it is not necessary to dismantle the gage after each star-gaging operation provided a suitable fixture is available for supporting the assembled gage as a unit.

(3) If the star gage is used infrequently—once in three months or so—it should be dismantled after the star-gaging operations are completed and the subassemblies and accessories should be lubricated as described in the following subparagraphs.

b. Head Tube. Remove the cap, guide and end piece from the head tube (par. 46 b (1) and (3).) Remove the operating rod nut and spring and withdraw the cone operating rod. Wipe the operating rod with a clean cloth, saturated with OIL, clock, or OIL, lubricating, preservative, light. Assemble the operating rod, spring and nut in the head tube. Assemble the end piece to the contact block. Pour a few drops of OIL, lubricating, preservative, light, into the hole in the end piece and move the cone operating rod back and forth a few times. Assemble the rifling guide cap and rifling guide to the head tube. Wipe the exterior surfaces of the head tube with a cloth, saturated with OIL, lubricating, preservative, light. Install the head tube in its proper place in the gage chest.

NOTE: If any oil is put on the measuring points, it will be necessary to remove the oil with SOLVENT, dry-cleaning, before using the gage to prevent erratic readings.

c. Indicator Housing Tube and Indicator Housing Assembly.

(1) Remove the indicator housing assembly from the indicator housing tube (par. 46 c).

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(2) Wipe the exterior surfaces of the tube and the exposed portion of the operating rod with a cloth, saturated with OIL, lubricating, preservative, light.

(3) Disassemble the indicator housing assembly as described in paragraph 46 e. Wipe all the metal parts except the dial indicator with a cloth, saturated with OIL, lubricating, preservative, light. Take particular care to see that the plunger is oiled.

(4) Reassemble the indicator housing assembly to the indicator housing tube and install in the gage chest.

d. **Accessories.** Wipe the size rings, extra rifling guide and wrenches with a cloth, dampened with OIL, lubricating, preservative, light. Install the accessories in their fixtures in the gage chest.

e. If the gage has a rotating member (adapter), wipe the exterior surfaces of the rotating member with a cloth, dampened with OIL, lubricating, preservative, light, and install in the gage chest. (The rotating member will not be disassembled.)

53. STORAGE.

a. If the gage is to be stored for an indefinite period, disassemble the head tube, indicator housing tube and indicator housing assembly as described in paragraph 46. Clean all the parts except the dial indicator with SOLVENT, dry-cleaning, and dry thoroughly. Apply COMPOUND, rust preventive, light. Reassemble the assemblies. Clean the size rings, rifling guides and wrenches with SOLVENT, dry-cleaning. Dry thoroughly and apply COMPOUND, rust preventive, light.

b. Wrap the head tube, indicator housing tube, indicator housing, accessories and rotating member, if the gage has one, in several layers of waxed or oilproof paper, and store in the proper fixtures in the gage chest.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

Section IX

BORE INSPECTING DEVICES

	Paragraph
Boroscopes	54
Mirror and light devices	55

54. BOROSCOPES.

a. **General.** Boroscopes are devices for visual examination of cannon tubes. Several types are manufactured under different trade names. Each boroscope includes: An illuminating head which contains a small mirror or a small prism and one or more lamps; a cable for connecting the lamps to the source of electric power directly, or to a transformer; one or more tubes, each containing at least one condensing lens; and an ocular attachment. Boroscopes are used at proving grounds and factories and will not be issued to field personnel.

b. Complete equipment for the visual examination of 20-mm guns is shown in figures 64 and 65. The boroscope is shipped as a single unit. A 6-volt lamp and a small stellite mirror are mounted at the forward end of a steel tube. The tube is graduated and marked in inches to 65 inches. The ocular attachment is secured to the rear end of the tube. This attachment has a knurled bearing surface for adjusting its focus and a neoprene eye protector. A single terminal rotating electrical contact is mounted just forward of the ocular attachment. The electric cable is connected at one end to the rotating contact and at the other end to a small transformer which fits directly into a 115-volt source of electric power. An adjustable stop, with set screw, is provided to hold the illuminating head at a constant distance from the muzzle when adjusting the focus and when viewing the bore. The boroscope has a magnification of approximately 8 X.

c. Equipment for the visual examination of 37-mm and 75-mm guns is shown in figures 66 and 67. The boroscope equipment includes three tubes, four illuminating heads, electrical accessories and extra lamps.

(1) DESCRIPTION.

(a) The head tube is graduated and marked in inches and feet to 2 ft, 5 in. It is provided with threaded bushings at both ends.

(b) The intermediate tube is graduated and marked in inches and feet from 2 ft, 8 in., to 7 ft, 5 in. Like the head tube, it is provided with threaded bushings at both ends.

(c) The tube with ocular attachment is graduated and marked in inches and feet from 7 ft, 8 in., to 10 ft, 2 in. It is provided with a

BORE INSPECTING DEVICES

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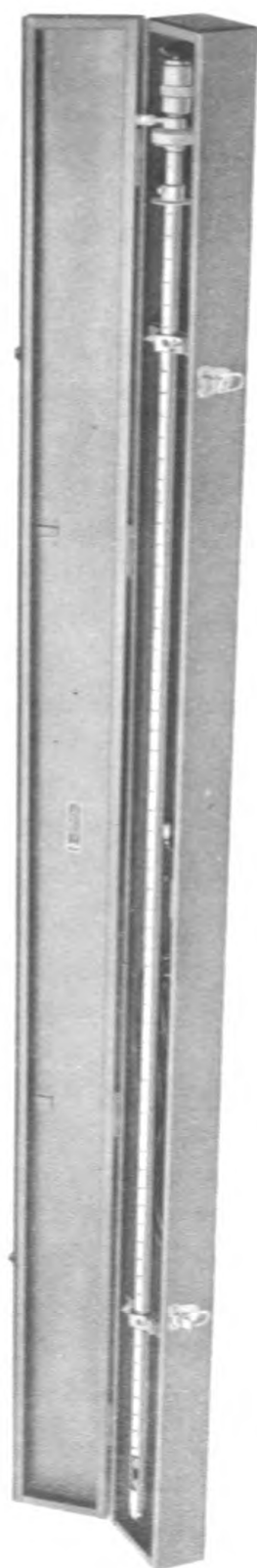


Figure 64—Boroscope for 20-mm Guns, with Cable and Extra Lamps, in Chest

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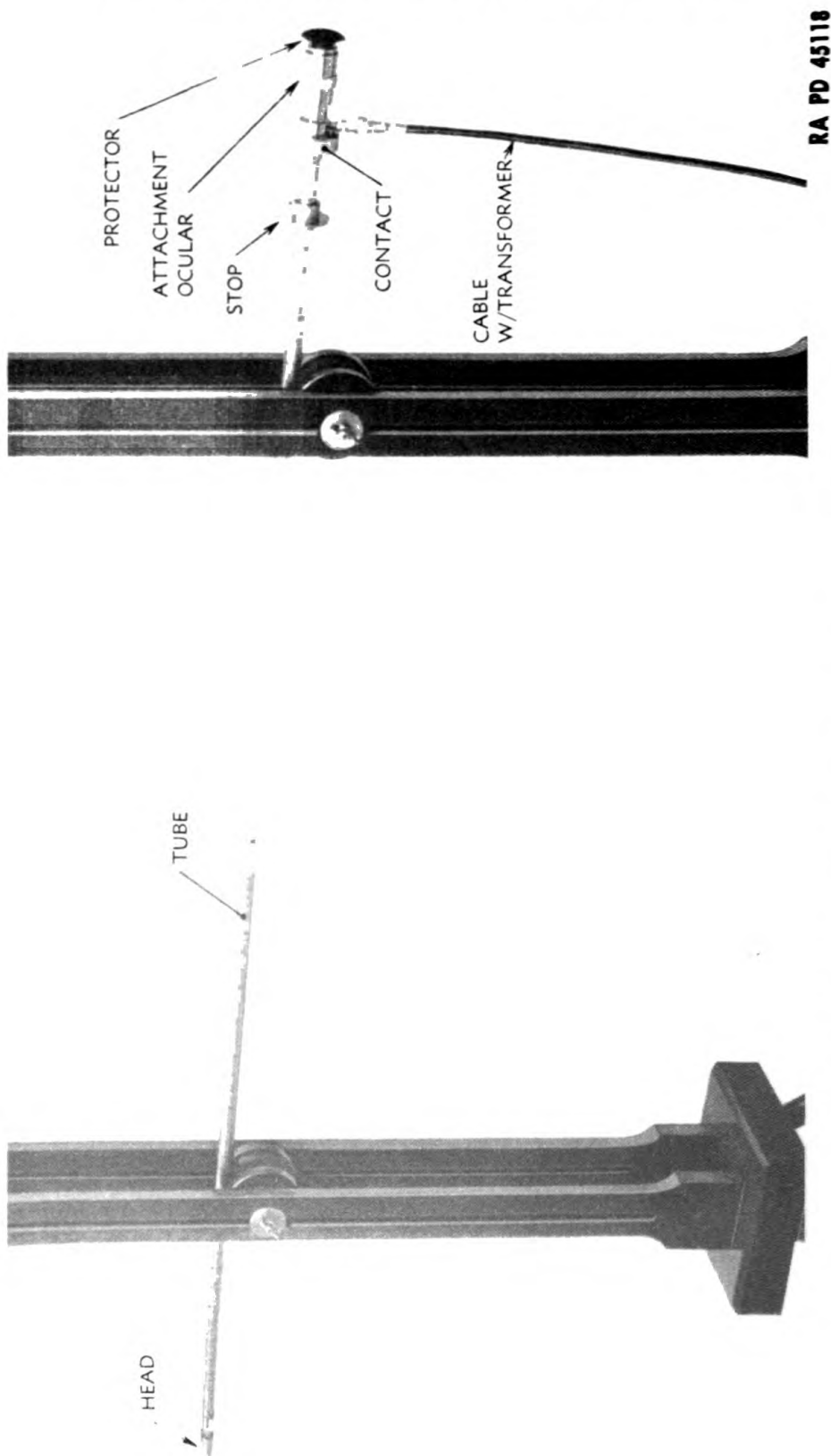


Figure 65—Boroscope for 20-mm Guns, Assembled

BORE INSPECTING DEVICES

threaded bushing at its forward end. This tube is also provided with a handwheel, for rotating the boroscope as a unit, and a rotating electrical contact.

(d) All of the tubes contain condensing lenses to concentrate the light from the illuminating head. An inverted or erect image is obtained depending on whether the intermediate tube is used or not used. The magnification of the assembled boroscope is approximately 6 X.

(e) Two illuminating heads are provided for 37-mm guns: one houses a mirror and lamp and the other houses a prism and lamp. Two similar heads are provided for 75-mm guns. When the illuminating head with mirror and lamp is used, the observer sees a portion of the bore which is downbore or offside, depending on the angle of tilt of the mirror, with respect to the illuminating head. When the illuminating head with prism and lamp is used, the observer sees a portion of the bore which is approximately perpendicular to the head.

(f) The end pieces of the housings of the illuminating heads are threaded to fit the threaded bushing at the forward end of the head tube.

(g) The electrical accessories include a transformer with cable and plug for stepping down voltage from 115 volts to 6 volts, and 30 feet of rubber-insulated cable with switch for connecting the transformer to the electrical contact on the boroscope.

(2) **ASSEMBLY AND USE.**

(a) *Assembly for 75-mm Guns.* Assemble an illuminating head to the head tube by screwing the illuminating head in place at the forward end of the head tube. Assemble the intermediate tube to the head tube by sliding the forward end of the intermediate tube over the bushing at the rear end of the head tube and screwing the two tubes "home." Assemble the tube with ocular attachment to the intermediate tube by sliding its forward end over the bushing at the rear end of the intermediate tube and screwing the two tubes "home."

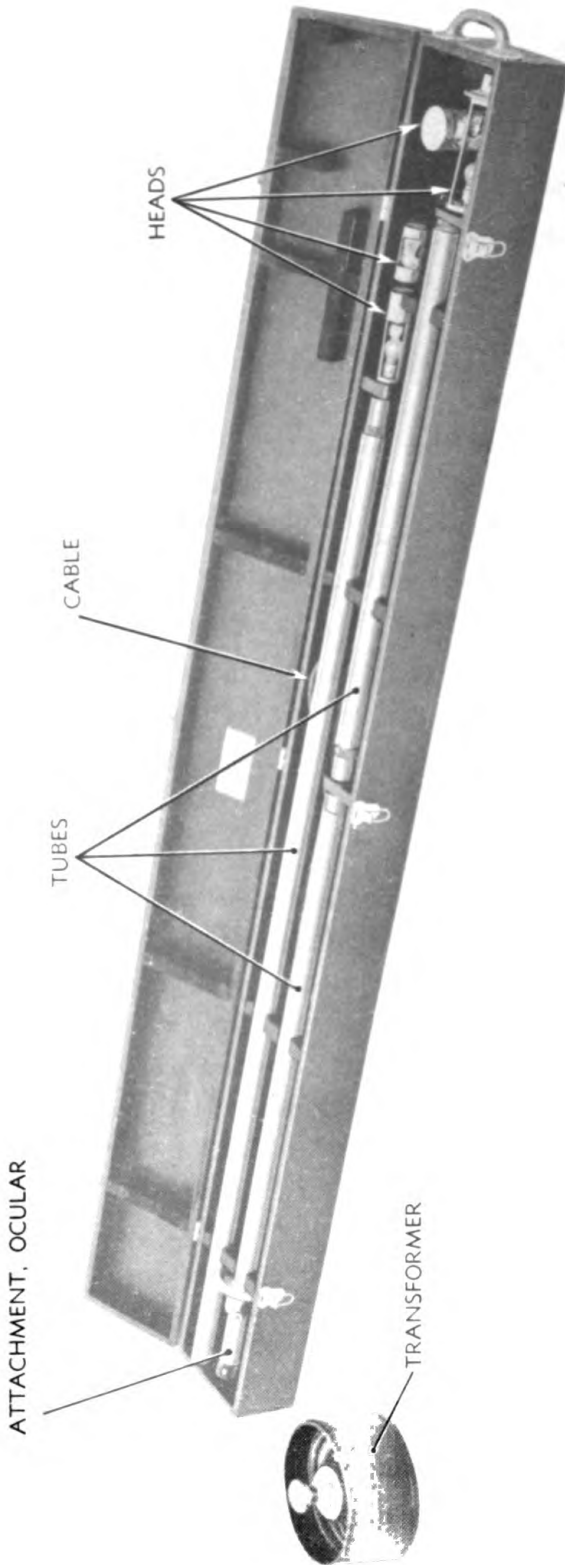
NOTE: When the tubes are screwed "home," approximately one inch of bushing will be exposed.

(b) *Assembly for 37-mm Guns.* Assemble an illuminating head, head tube and tube with ocular attachment.

(c) The focus of the ocular attachment is adjusted to the observer's eyes by rotating the eyepiece tube.

CAUTION: The cable connecting the rotating contact on the boroscope to the transformer should not be connected to the rotating contact until the boroscope is assembled and installed in the gun.

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Figure 66—Boroscope for 37-mm and 75-mm Guns, with Accessories, in Chest

BORE INSPECTING DEVICES

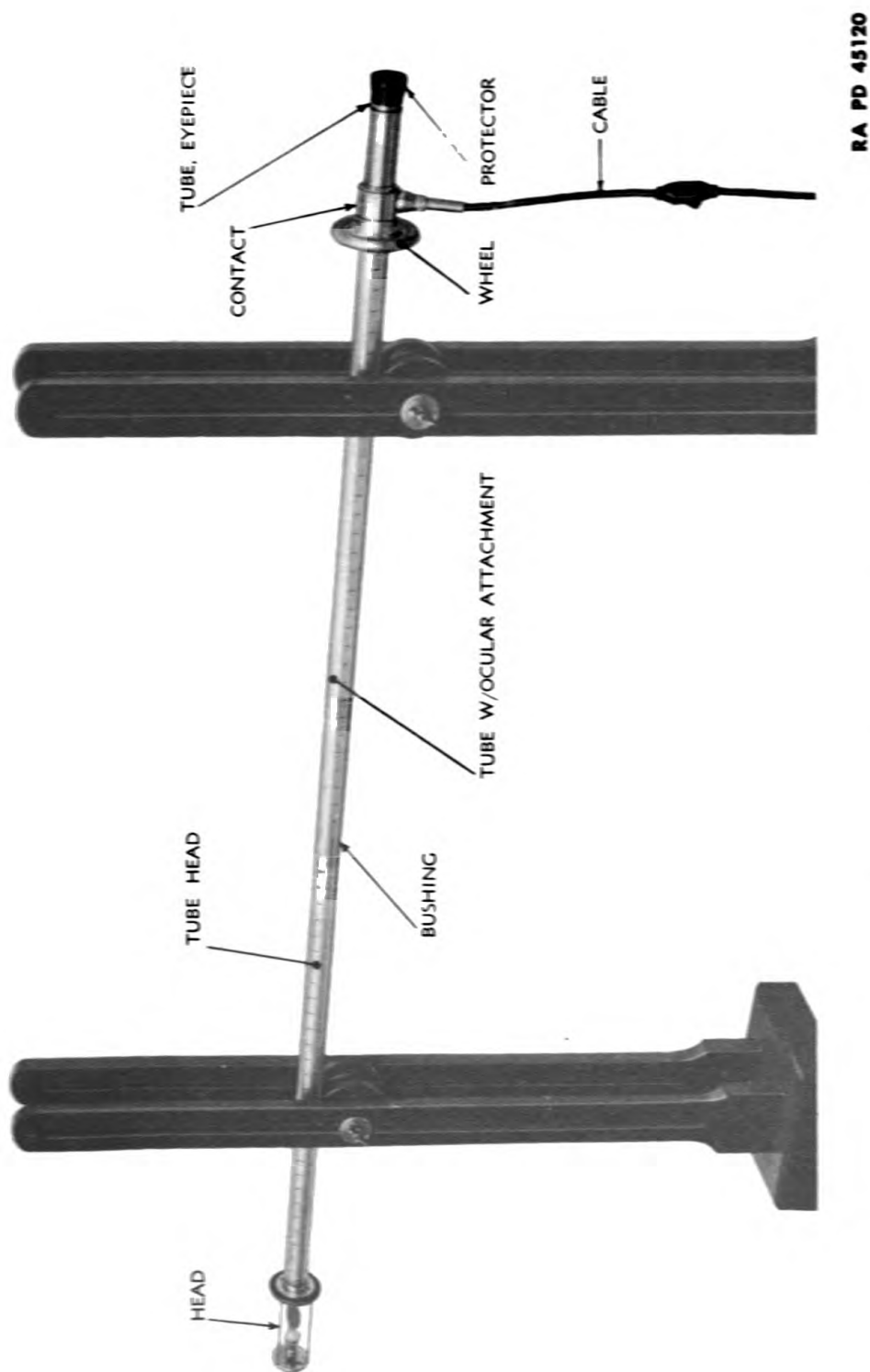


Figure 67—Boroscope for 37-mm Guns, Assembled

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
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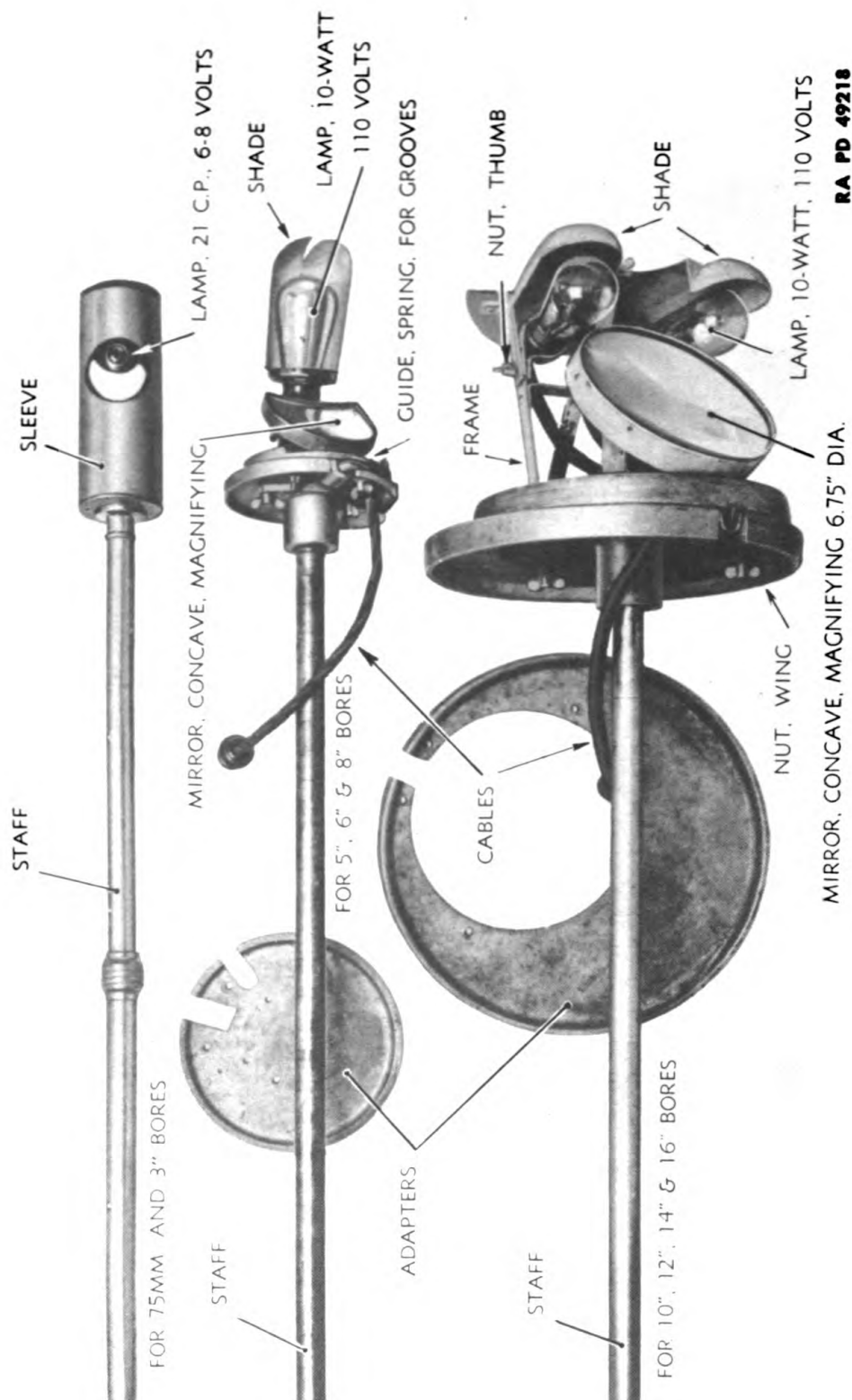


Figure 68—Mirror and Light Devices for Inspecting Cannon Tubes

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BORE INSPECTING DEVICES

55. MIRROR AND LIGHT DEVICES.

a. The mirror and light devices illustrated in figure 68 utilize a convex lens or a concave mirror for magnifying the portion of the bore being examined. These devices are installed in cannon tubes and used precisely as boroscopes provided with heads having mirrors.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

PART TWO

IMPRESSION OUTFITS

Section X

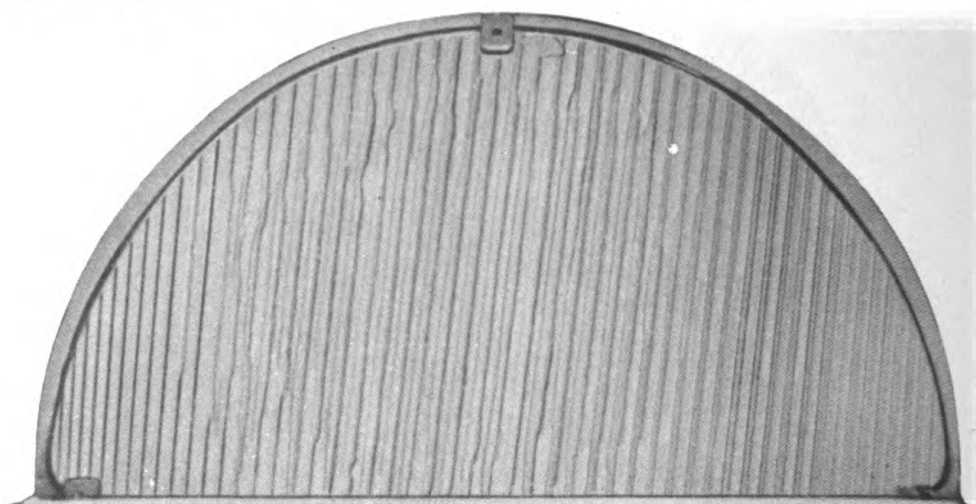
IMPRESSION OUTFITS

Paragraph

General	56
Equipment	57
Making plaster of paris impressions	58
Making gutta-percha impressions	59

56. GENERAL.

a. When the star-gaging measurements are completed, the cannon bore is inspected visually with the aid of mirror and light devices (fig. 68). An area which appears faulty when inspected visually may be only a discoloration of the metal or a lightly coated rust spot. Photographs may be made of those portions of the bore which show unusual

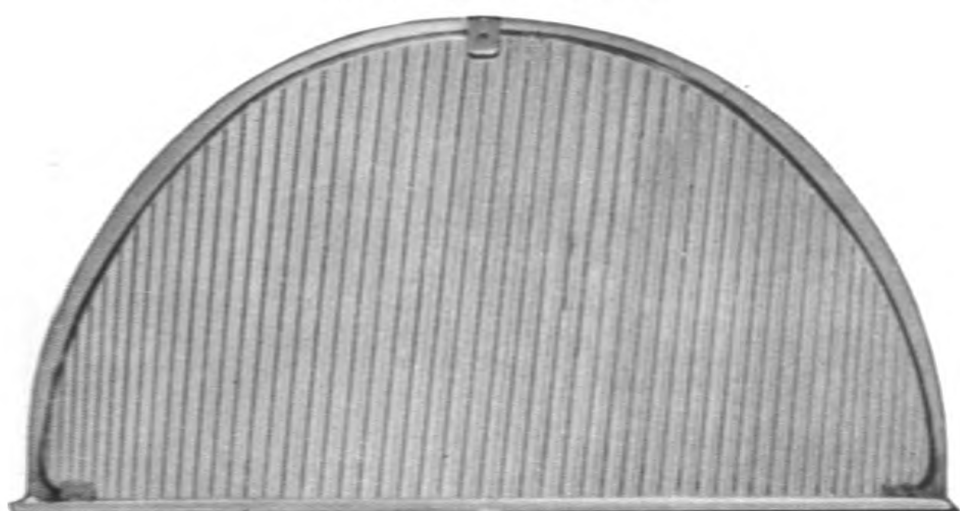


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**Figure 69—Large Section of Bore Showing Badly Coppered Condition
(16-inch Howitzer M1920)**

wear or irregularities with a suitable camera and with a mirror and light installed in the bore. Figure 69 shows a badly damaged large section of a 16-inch Howitzer M1920, approximately 206 inches from the muzzle end. The photograph was taken with a mirror and light installed in the bore. The lands and grooves are badly coppered and the tops of the lands have been "chewed up" and "flattened out." Figure 70 shows a

IMPRESSION OUTFITS



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**Figure 70—Small Section of Bore Showing Coppered Condition
(16-inch Howitzer M1920)**

damaged small section of the same howitzer, at approximately the same distance from the muzzle end.

b. If measurements are to be taken of irregularities such as pastilles, pits, cracks, dents which have raised a bur, etc., plaster of paris or gutta-percha impressions are made. Plaster of paris or gutta-percha impressions constitute a negative record of a section of the bore and show accurately the three-dimensional characteristics of the damaged section.

c. Photographs (figs. 71 and 72) are made of all impressions which show a faulty or abnormal condition and are filed as a part of the star-gage report.

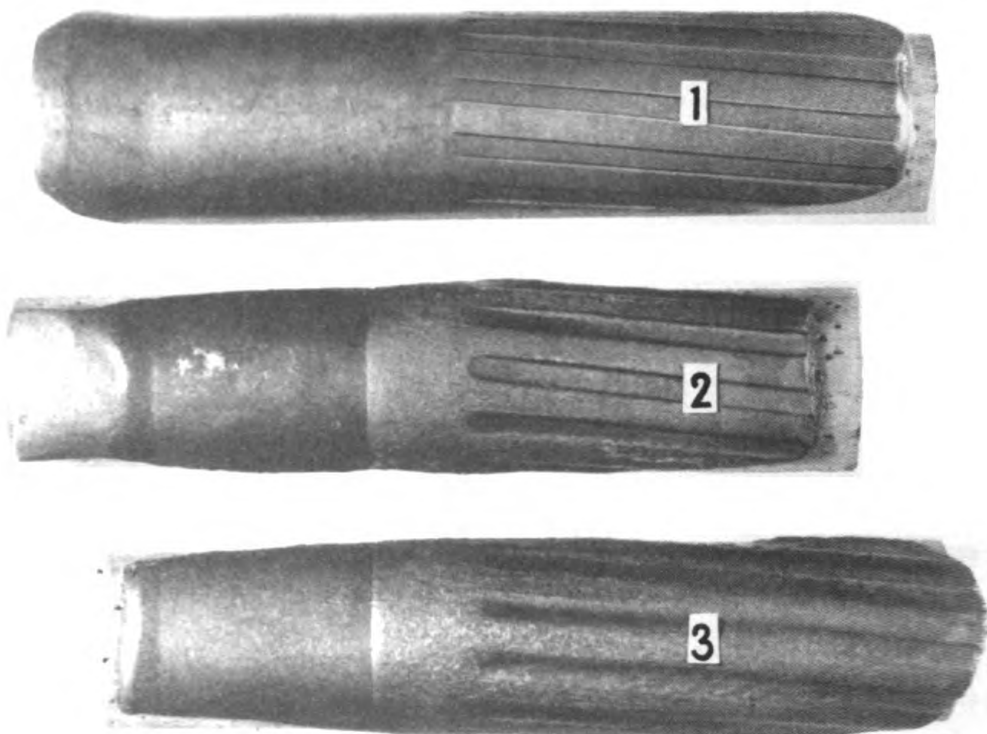
d. If very accurate measurements are to be made of the dimensions of faults such as pastilles, cracks, etc., it is preferable to use plaster of paris as the surface is harder than gutta-percha. Impressions made of plaster of paris do not have the "folds" and air cells sometimes found in the gutta-percha impressions and have the additional advantage of remaining accurate almost indefinitely. Gutta-percha impressions shrink with time.

57. EQUIPMENT.

a. **Plaster of Paris Impressions.** Generally, the only special equipment required for plaster of paris impressions is the material itself. In some cases, special means are provided to hold the plaster of paris in place (par. 58 d).

b. **Gutta-percha Impressions.** Special equipment is required for gutta-percha impressions, most of it available locally. The equipment

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Figure 71—Gutta-Percha Impressions of 37-mm Tube MIA2 Showing Erosion Extending Rearward to Front End of Cartridge Case. 1. Before Firing. 2. After 516 Rounds. 3. After 1,216 Rounds

is illustrated in figure 73 and is described in the following subparagraphs. Personnel will be supplied with gutta-percha only and will have to improvise or secure the rest of the material locally.

(1) IMPRESSION BLOCKS.

(a) The impression block (fig. 73) is made of clear, white pine, or a similar light, close-grained, well-seasoned wood. The lengths of these blocks are 3 to 6 inches for cannon of 37-mm caliber and 6 to 12 inches for cannon of 75-mm caliber and above. Special lengths may be required when it is necessary to show the full extent of a fault.

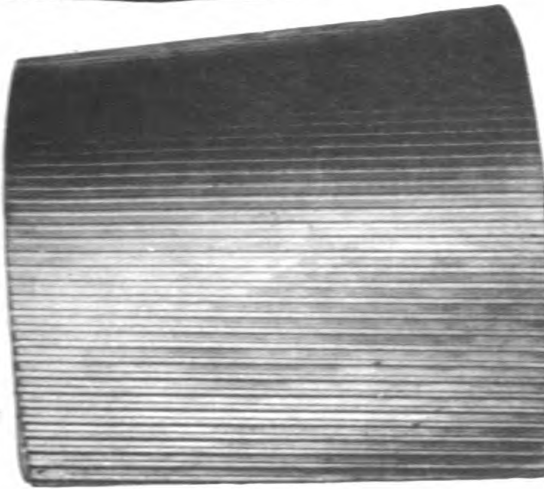
(b) The block is fashioned from a semi-cylindrical piece. The lower or flat surface of the block tapers lengthwise at the rate of $\frac{1}{2}$ inch for each 12 inches of length and the upper or curved surface tapers at the same rate but in the opposite direction. The periphery of the larger end of the block should not exceed one-third the periphery of the cannon bore, and the curvature of the top of the upper surface of the block should match that of the cannon bore. Shallow perforations $\frac{1}{8}$ - to $\frac{1}{4}$ -inch diameter and about $\frac{1}{4}$ -inch deep are punched in the top surface of the block to cause the impression material to stick to the surface.

IMPRESSON OUTFITS

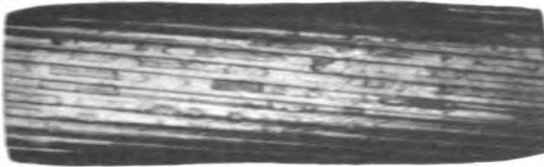


DAMAGE CAUSED BY
A LOW ORDER
"PREMATURE"
12 IN. GUN M1895

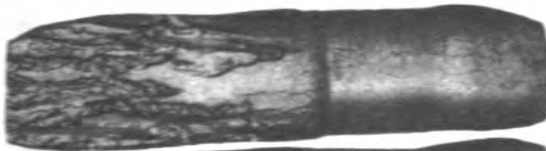
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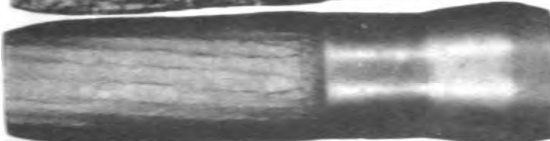
UNEVEN WEAR ON THE LANDS
16 IN. GUN M1919 DRIVING LANDS
WORN ALMOST TO THE GROOVE
DEPTH, (CENTER OF IMPRESSION)
WHILE THE LANDS IN THE FORE
GROUND ARE OF NORMAL HEIGHT



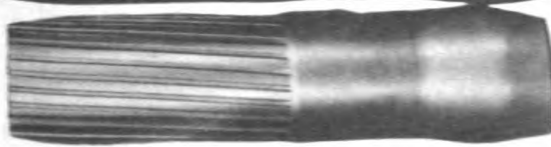
COPPER
DEPOSIT
105-MM
A.A. GUN
M1927



ABNORMAL
EROSION
800 ROUNDS
OVER
ACCURACY
LIFE OF
GUN



END OF
GUN
ACCURACY
LIFE



BEFORE
PROOF-
FIRING

3 IN. A.A. GUN

Figure 72—Cannon Bore Gutter-Percha Impressions

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

Nine perforations (three rows of three) are sufficient. A $\frac{13}{16}$ -inch hole is bored lengthwise through the block to receive the distance rod.

(2) **DISTANCE RODS** (fig. 73). Distance rods are made of bar steel in various lengths. The length of rod used depends on the cannon and the location of the fault. A $\frac{1}{4}$ -inch rod is required for the 37-mm cannon, $\frac{1}{2}$ -inch rod for 75-mm to 105-mm cannon, $\frac{5}{8}$ -inch rod for 4.7-inch to 8-inch cannon and $\frac{3}{4}$ -inch rod for cannon of 10-inch caliber and above. From 12 to 27 inches of one end of the rod is threaded. The exact length of the threaded portion depends on the cannon and the location of the fault. One inch of the other end is also threaded. Two nuts and washers are required, one for each end of the distance rod.

(3) **DISTANCE PIECES** (fig. 73). Distance pieces are made in the field from $\frac{3}{8}$ -, $\frac{1}{2}$ -, $\frac{3}{4}$ - and 1-inch galvanized iron pipe. Size and length depend on requirements. They act as sleeves between the impression block and the rear end of the distance rod.

(4) **FACE PIECE** (fig. 73). The face piece is a steel bar used to fix the distance from the breech or muzzle to the center of the impression block. A steel bar, $\frac{3}{4}$ by $\frac{3}{4}$ by 24 inches, drilled centrally in its face with a $\frac{13}{16}$ -inch hole will suffice for all cannon measurements. The face piece may be drilled and tapped at right angles to its central hole for a set screw to clamp it to the distance rod.

(5) **WEDGE AND STAFF** (fig. 73). The wedge is used to press the impression block against the bore while the impression is being made. It is made of hardwood and is about twice the length of the impression block. One surface is cylindrical to match the cannon bore and the other surface is flat and tapers lengthwise, $\frac{1}{2}$ -inch per 12-inch length, to match the impression block. Its size is such that block and wedge fitted together have a combined diameter approximately $\frac{1}{8}$ -inch less than the cannon bore when the wedge is retracted. A hole may be bored in the larger end of the wedge to receive the end of a wooden staff. The staff is secured to the wedge by its "drive fit" supplemented by two long wood screws. It may be provided with a ferrule at its outer end to prevent splitting.

NOTE: In cannon of small bore where the cannon can be rotated to place the fault on the bottom, it is not necessary that wedge and staff be attached. The wedge can be moved into place by pounding on it with any staff of suitable length and weight.

(6) **MISCELLANEOUS** (fig. 73). The remainder of the equipment required for making gutta-percha bore impressions includes the following:

(a) Sufficient gutta-percha impression material to meet the immediate requirements. Normally, the $\frac{1}{4}$ -inch by 5-inch by 20-inch slab

IMPRESSION OUTFITS

is sufficient for making impressions of small faults. However, the material may be obtained in sizes up to $\frac{5}{8}$ -inch thick.

(b) One can of powdered or flake graphite.

(c) A means for heating water. A fire pot with self-contained air pump and containing about 2 quarts of gasoline is frequently most convenient.

(d) One 14-quart galvanized iron bucket or other suitable container in which water may be heated.

(e) One pair of 10-inch tweezers or long-nose tongs.

(f) One length of $\frac{1}{4}$ -, $\frac{1}{2}$ -, $\frac{5}{8}$ - or $\frac{3}{4}$ -inch bar steel (round).

(g) Two each, regular hexagon nuts, sizes $\frac{1}{4}$ -, $\frac{1}{2}$ -, $\frac{5}{8}$ - or $\frac{3}{4}$ -inch and corresponding plain, steel washers.

(h) One length of galvanized iron pipe of suitable diameter.

(i) A hacksaw for cutting the distance piece, a die for threading the distance rod and a wrench to tighten the nuts on the distance rod.

(j) A hardwood roller approximately $2\frac{1}{2}$ inches in diameter by 18 inches long and a smooth board, 1 inch by 15 inches by 26 inches, will be required for rolling the gutta-percha if received in blocks thicker than $\frac{1}{4}$ -inch, and for remolding old impressions.

(k) One 3-pound sledge with handle for large caliber bores. (See NOTE in subparagraph (5).)

58. MAKING PLASTER OF PARIS IMPRESSIONS.

a. Clean the cannon bore thoroughly.

b. Place the plaster of paris, which is received in powdered form, in any convenient container. Add water and mix by means of a wooden stick or paddle. One and one-half to two pounds of plaster of paris will be adequate for most cases. Sufficient water is added to obtain a freely flowing plastic material similar to heavy cream. The water should be added in small amounts and care should be taken to avoid getting the mixture too thin.

c. Pour the mixture over the desired area in the bottom of the bore with a wooden ladle having a handle of appropriate length and allow it to "set" for three-quarters of an hour or longer. The coating of plaster of paris should be at least $\frac{1}{2}$ -inch thick.

d. If the fault is at the top of the bore or on a side wall in a cannon of large caliber that cannot be rotated to bring the fault to the bottom, a locally improvised block and staff or the impression block and wedge previously described must be used to hold the plaster of paris mixture in place. A block of wood which has a curved surface matching the cannon bore is coated with a layer of plaster of paris ($\frac{1}{4}$ - to $\frac{1}{2}$ -inch

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

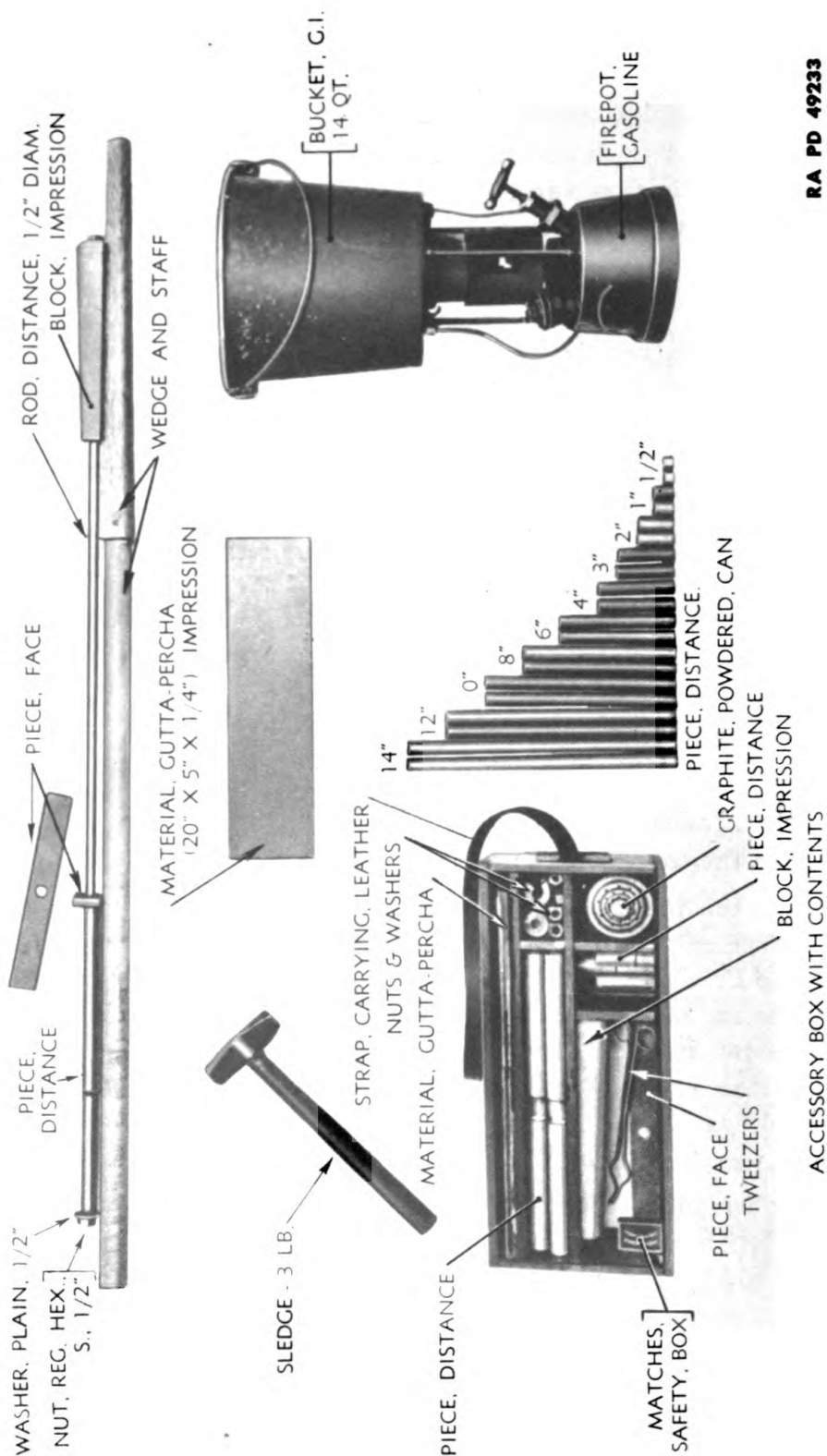


Figure 73—Cannon Bore Impression-making Equipment

IMPRESSION OUTFITS

thick) and inserted into the bore and pressed lightly against the damaged area. Perforations are made in the block to cause the material to adhere to it. The block must be held against the bore for at least three-quarters of an hour.

e. If the suspected fault is at the muzzle or breech, the plaster of paris mixture is retained in the bore by an improvised wall of wood, putty, clay or other suitable material placed in the muzzle or breech.

f. To remove the plaster of paris impression after it has set, work a long, pointed stick around the edges of the impression until it comes loose. Work the stick up and down or from side to side. Do not pry loose by forcing the impression lengthwise along the bore. Care must be exercised in removing the impression and handling it because it is brittle and easily broken. Place an identifying number or title on the impression.

CAUTION: The plastic material dries very rapidly. A minimum of time should elapse, therefore, between preparing the mixture and making the impression.

59. MAKING GUTTA-PERCHA IMPRESSIONS.

a. Clean the cannon bore thoroughly.

b. Place the bucket, about half full of water, on the fire pot and allow the water to warm up. Do not permit the water to boil.

c. While the water is heating, insert a suitable distance rod in the impression block so that the end with the 1-inch thread projects slightly and install a suitable nut and washer at this end. Install the face piece so that the distance from the center of the block to the face piece is equal to the distance from the fault to the muzzle or breech and tighten the set screw. Install a distance piece of sufficient length to cover the 12 to 27 inches of exposed thread and install a washer and nut (fig. 73).

d. Drive a staff of suitable dimensions into the thick end of the wedge and install wood screws.

e. Place one or more slabs of gutta-percha in the heated water and allow the gutta-percha to remain until soft and pliable. Test frequently with the forefinger and thumb for pliability. The gutta-percha is suitable for use when it has a consistency similar to that of soft dough.

CAUTION: Do not allow the slabs to touch each other. Do not allow the water to boil.

f. When soft, lift the gutta-percha from the bucket by means of the tweezers and lay it on the rolling board after first wetting the board to prevent sticking. Rub a small amount of flake or powdered graphite on the roller and roll the gutta-percha out flat to a uniform thickness of about $\frac{1}{4}$ -inch. If slabs of $\frac{1}{4}$ -inch thickness are available, no rolling will be necessary.

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
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g. Wet the curved surface of the impression block. Place the softened slab of gutta-percha on the wet surface and mold to shape, pressing the gutta-percha slightly into the perforations. Rub the gutta-percha by hand to remove all bubbles and water and then rub flake or powdered graphite on the gutta-percha evenly and lightly to prevent its sticking to the cannon bore.

NOTE: It may be necessary to reheat the gutta-percha to make it sufficiently pliable.

h. Insert the impression block with its gutta-percha coating into the bore of the cannon until the face piece strikes the muzzle or breech and rotate the block until the gutta-percha adequately covers the damaged area of the bore.

i. Insert the wedge, flat side against the flat side of the block, and drive on the end of the wedge staff until the gutta-percha is seen to squeeze out. Leave the impression in the bore for at least 1 to 1½ hours. The time necessary will vary according to temperature conditions. It may be necessary to shade the gun by means of a tarpaulin placed to allow free passage of air, or to make the impression in the early morning.

j. After the impression is cool and hardened, back the wedge all the way out of the bore without disturbing the impression by pressing a bar of suitable length against the thin end. The face piece must remain against the muzzle, or breech, during this operation.

k. Remove the impression block with impression very carefully by moving the distance piece and rod up and down and from side to side. Do not pull or push the impression block along the bore.

l. Remove the impression from the impression block by lifting it from the several perforations. A short stick may be useful in this operation. Do not trim until the impression is thoroughly hardened. Dust the impression lightly with graphite placed on a soft cloth. Place an identifying number or title on the impression.

NOTE: Impressions may shrink, warp and crack if kept over a year.

m. When an impression has fully served its purpose, it may be re-worked for other impressions. However, it may not be practical to use the material after it has aged about one year as it becomes brittle with age.

PART THREE

PRESSURE GAGES

Section XI

PRESSURE GAGES

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Shipment	64
Assembly and use of pressure gages	65
Records	66
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Storage	69
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60. GENERAL.

a. Pressure gages of the crusher-type are used to determine the maximum powder pressure produced in the powder chamber during the combustion of the propelling charge. Pressures are measured in proof-firing of guns and powder, in target practice, when checking the cause of erratic firings and in experimental firings made during development of guns and ammunition as an aid in controlling the uniformity of action of the guns and ammunition.

61. DESCRIPTION AND FUNCTIONING.

a. **General.** Four sizes of crusher-type pressure gage are used—large cannon, medium cannon, small cannon and Navy-type small cannon. The large cannon pressure gage is designed for measuring pressures in all cannon of 8-inch caliber and higher. The medium cannon gage is designed for cannon of caliber 2.95 inches to 155 millimeters, inclusive, but may be used for cannon of larger caliber. The small cannon gage and the Navy-type small cannon gage are designed for cannon of caliber under 2.95 inches. The Navy-type small cannon gage is particularly adapted for 37-mm guns.

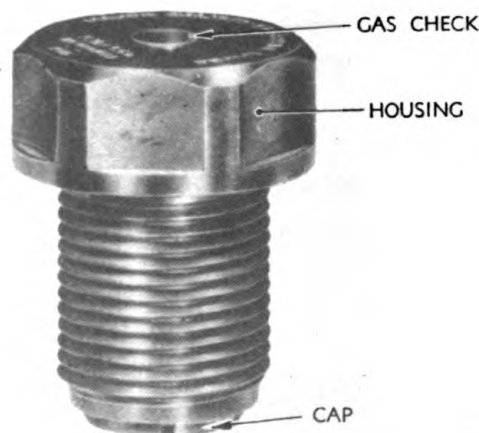
NOTE: The large cannon, medium cannon and small cannon pressure gages are also called major caliber, medium caliber and minor caliber pressure gages, respectively.

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES****b. Description.**

(1) The crusher-type pressure gages consist essentially of a steel cap, a copper gas check and a steel housing which contains a steel piston and a copper cylinder. The steel cap closes the housing at one end and the gas check closes the housing at the other end (fig. 74).

(2) The housing of the large cannon pressure gage has an exterior thread to fit the threaded holes in the obturator spindle of the breech-block of large caliber guns. Blank plugs are supplied with the cannon for protecting the seats when the pressure gages are not in use. The piston area of the large cannon gage is one-tenth square inch.

(3) The medium cannon, small cannon and Navy-type small cannon pressure gages are of the "loose" type. They are placed under a powder bag or in the bottom of a cartridge case (par. 65 c). The piston area of the medium cannon gage is one-tenth square inch. The piston area of the small cannon and the Navy-type small cannon gages are the same, one-thirtieth square inch.



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Figure 74—Exterior View of Large Cannon Pressure Gage

c. Functioning. All of the crusher-type pressure gages function in the same manner. When the propellant charge ignites, the pressure of the rapidly expanding charge is exerted against the gas check. This pressure is transmitted to the steel piston causing it to move and compress the copper pressure cylinder against the steel closing cap which is screwed firmly into the gage housing. The compression of the cylinder—difference in height before and after firing—is measured with a micrometer caliper. The compression depends on the maximum powder pressure in the powder chamber. It may be expressed in terms of pressure by reference to target tables which are empirical tables relating

PRESSURE GAGES

the compressions of copper cylinders to the pressures which produce these compressions (par. 62 b).

62. CALIBRATION.

a. **Initial Compression.** In the manufacture of the copper cylinders, they are given different initial static compressions, in lots. The use of cylinders having an initial "set" prevents excessive compressions and also prevents the hammer effect produced by the kinetic energy acquired by the piston during a relatively long travel.

b. **Tarage Tables.** Representative samples of copper cylinders are subjected to various pressures in a hydraulic press and the corresponding compressions are plotted as a curve. From this curve, tables are prepared for battery use.

(1) Table III gives the compression "sets" corresponding to various static pressures for cylinders which have been calibrated from 6,000 to 50,000 pounds per square inch in steps of 1,000. The first column gives the static pressure. The second column gives the total "set" due to the corresponding pressure in the first column. The third and following columns give the partial "sets" due to a pressure of 1,000 pounds per square inch in the range stated at the top of the column. For example, a cylinder which has an initial compression of 18,000 pounds per square inch has a total set of 0.1007 inch for a pressure of 24,000 pounds per square inch. The partial "set" due to the additional pressure (24,000 minus 18,000 or 6,000 pounds per square inch) is 0.0348-inch.

(2) To expedite the reading of results, particularly in field use, a table similar to Table II is interpolated from the one made by the manufacturer for every hundred pounds pressure. Table II gives the partial "sets" from 34,000 to 50,000 pounds per square inch, in steps of one hundred, for cylinders having an initial compression of 34,000 pounds per square inch. Such a table is constructed for each lot of cylinders having different initial compressions.

63. ACCURACY OF GAGES.

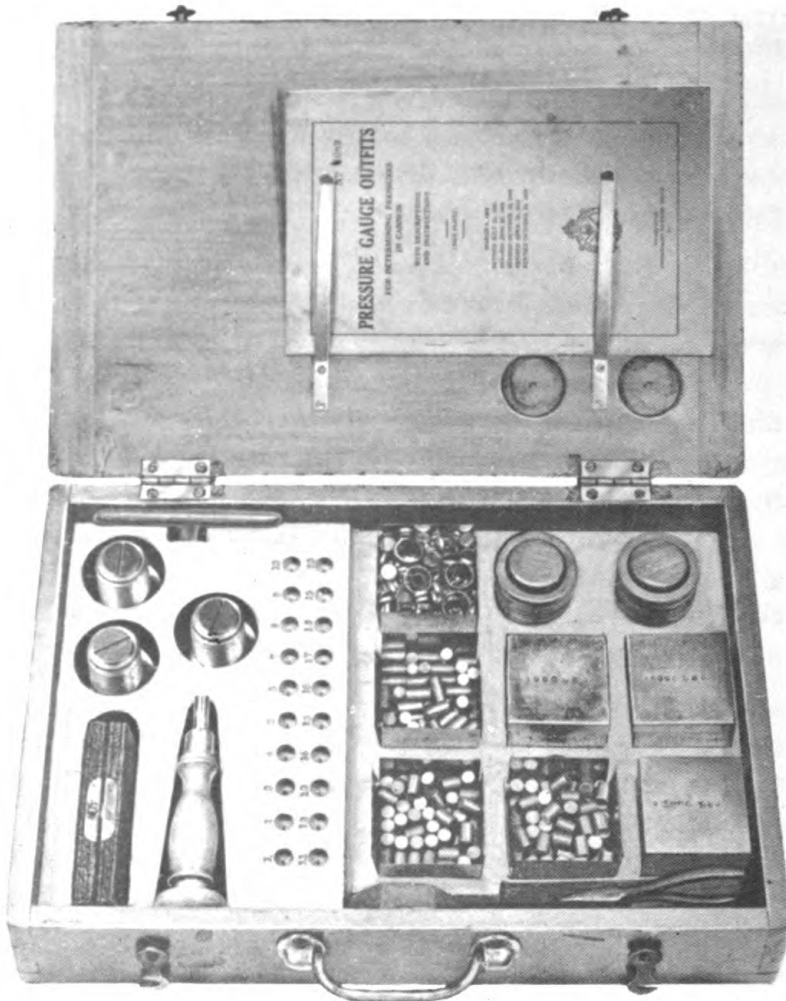
a. The pressure data obtained with crusher-type gages are not absolute values, chiefly because of the difference in the time the pressure is applied in the static press used for calibration and in the cannon powder chamber. In the static compression machine, each successive load is allowed to act on the cylinders for approximately 15 seconds, whereas the pressure generated by the firing of the cannon reaches its maximum in 0.004 second or less, and is maintained for a much shorter time, in some cases 0.0001 second only. The pressures given by crusher gages placed in the chamber of a gun are accepted as being about 80 to 85 percent of the actual maximum pressure.

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b. The probable error of an average pressure determination is 600 pounds per square inch, or more.

64. SHIPMENT.

a. The pressure gage outfits are shipped in chests complete with accessories. The pressure gage outfit for large cannon is shown in figure



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Figure 75—Pressure Gage Outfit for Large Cannon, Complete, in Chest

75. It will be noted that the chest contains several boxes of copper cylinders, each box containing cylinders of different initial compressions.

65. ASSEMBLY AND USE OF PRESSURE GAGES.

a. Initial Measurements of Cylinders.

(1) Select pressure gages suitable for the caliber of the cannon in which they are to be used (par. 61 a).

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(2) Select copper cylinders which have an initial compression of 4,000 to 7,000 pounds less than the expected maximum pressure in the powder chamber. Record the initial compression on the record form opposite I. C. (fig. 78).

NOTE: If no "set" is obtained after firing, a pressure cylinder of lower initial compression should be used for the next round. If the observed "set" is much greater than anticipated, a cylinder of higher initial compression should be used for the next round.

(3) Make sure that the ends of the cylinders are entirely free from dirt. Measure the lengths of several copper cylinders of the same initial compression to one ten-thousandth of an inch with a micrometer caliper (last decimal place estimated). Use only a moderate pressure on the knurled surface of the caliper. Use only those cylinders which have a variation in length of less than 0.0030 inch.

(4) Place each cylinder in one of the 20 numbered holes of the gage chest. Record the measurement to ten-thousandths of an inch on the record form opposite I. M. (initial measurements) in the column (fig. 78) whose number corresponds to that of the hole in the gage chest.

b. Preparing the Gage.

(1) Hold the gage housing firmly by means of the housing wrench and unscrew the closing cap with the cap wrench (figs. 76 and 77). The medium cannon gage is provided with a teat wrench and a tee-teat and reamer wrench which duplicate the functions of the housing wrench and cap wrench, respectively.

(2) Remove the copper washer (medium cannon and small cannon gages). Examine the washer for defects. If it shows roughness, cracks, burns or any other defects caused by the powder gases, replace with a new washer.

(3) Push the piston out of the gage with the gas check inserter (fig. 77). Clean the piston with a piece of soft cloth, dampened with CLEANER, rifle bore, and wipe dry.

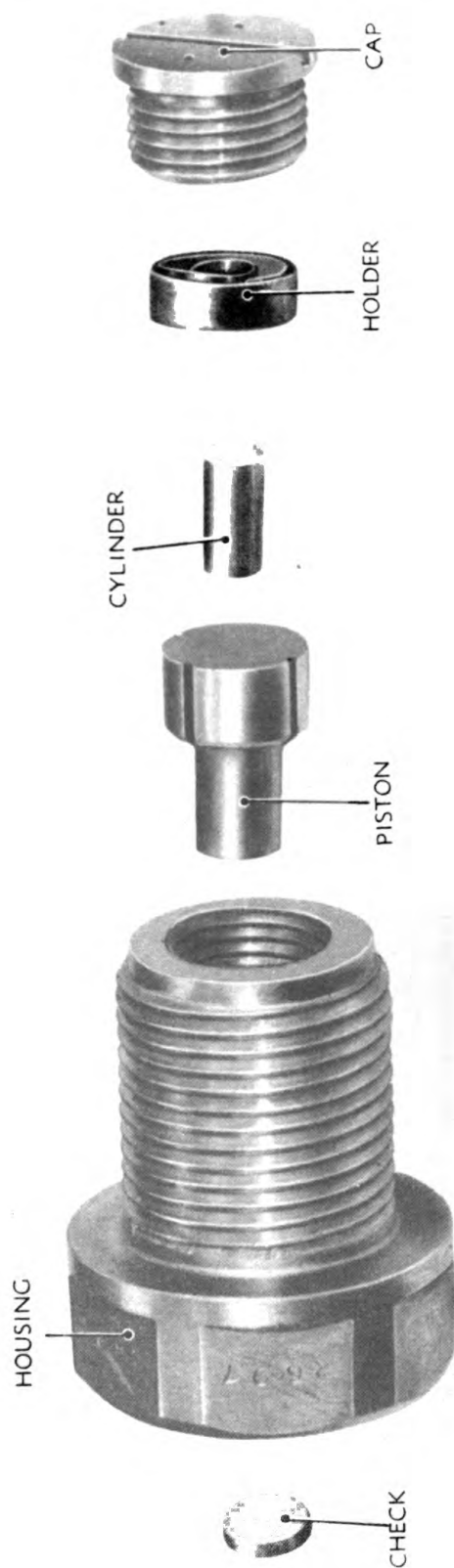
(4) Clean the inside of the gage housing by using CLEANER, rifle bore, on cloth and long-nose pliers (fig. 77).

(5) Examine the piston and housing carefully for any channels that may have burned in the piston, piston seat or housing threads. Check that the piston enters the bore of the gage freely by inserting the piston and tapping the side of the gage until it is fully seated.

CAUTION: Do not use a gage unless all the parts are in proper working condition.

(6) Put a drop of OIL, lubricating, preservative, light, on each end of the piston and insert the piston in the bore of the gage housing.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES



RA PD 49235

Figure 76—Exploded View of Large Cannon Pressure Gage

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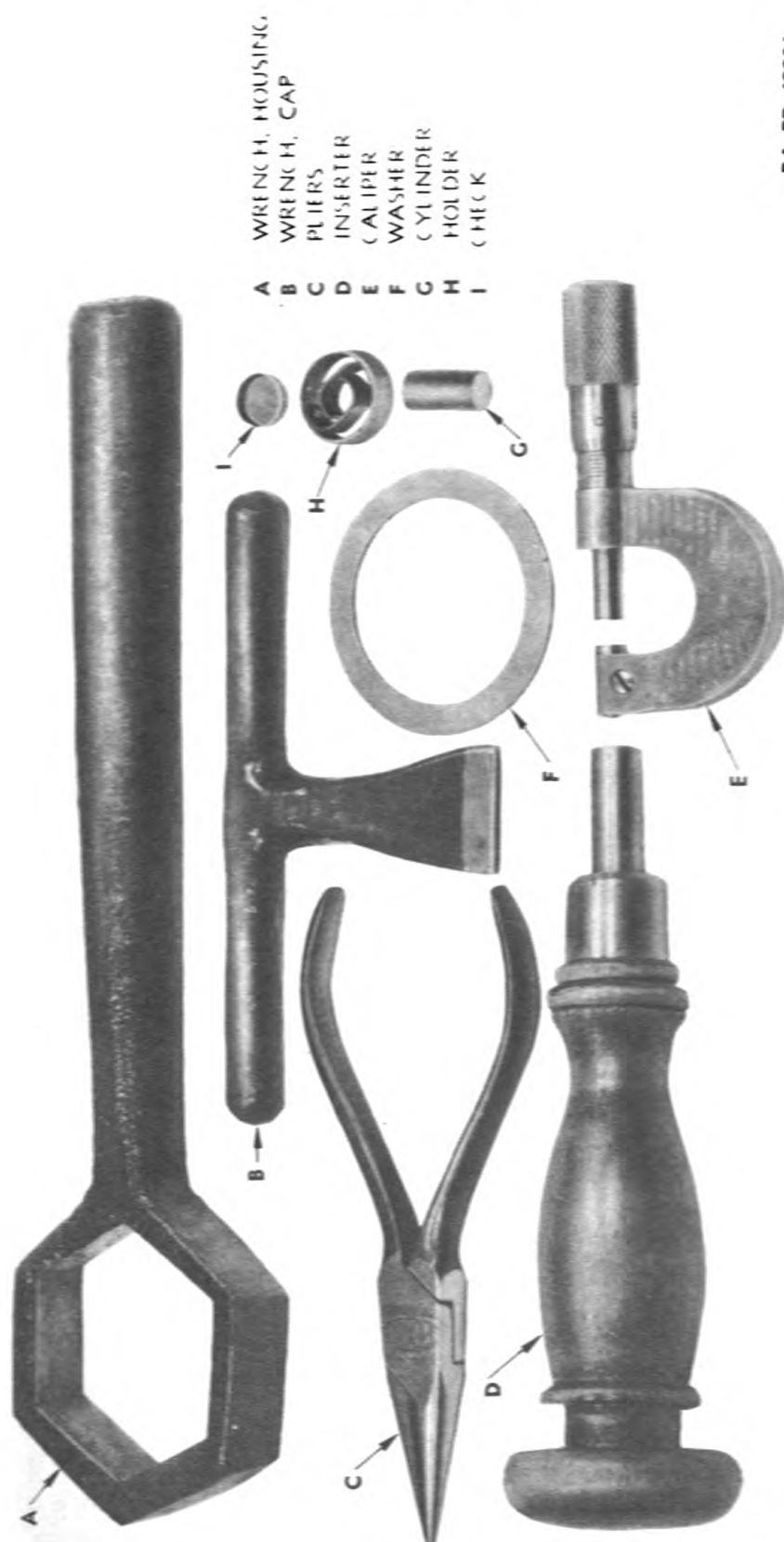


Figure 77 — Accessories for Large Cannon Pressure Gage

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES**

(7) Install a copper cylinder in a cylinder holder so that it is supported in the middle of its length.

NOTE: Cylinder holders are used only with large cannon gages and with medium cannon gages for cylinders above 18,000 pounds initial compression.

(8) Insert the cylinder, and the holder, if one is used, in a gage housing so that the cylinder rests on end in the center of the piston anvil.

(9) Record the number of the gage housing in which the cylinder was installed on the record form (fig. 78).

(10) Put the copper washer in place (medium cannon and small cannon gages) and screw in the closing cap, setting it up tightly with the proper wrench.

(11) Place a copper gas check in the bore of the gage (bottom of cup next to piston) and press it firmly against the head of the piston, making sure that the copper cylinder has no play between the piston anvil and the closing cap.

(12) Partially fill the gas check with GREASE, O. D., No. 0, to insure a gastight fit.

(13) Carry out steps b (1) to b (12) for as many additional gages as are to be used in the pressure measurements, taking care to record the number of each gage housing and the initial length measurement of each cylinder on the record form.

(14) Arrange the gages in a suitable rack, or in their compartments in the gage chest, in the order in which they are to be used.

c. Installing the Gage.

(1) **LARGE CANNON PRESSURE GAGE.** Two gages are used in one test firing of cannon of 8-inch and higher caliber. Remove the plugs and washers from the mushroom head of the obturator spindle. Examine each washer for defects. If it is rough or uneven, or if any portion is burned, replace with a new washer. Install the washers and gages, screwing the gages firmly in place.

(2) **MEDIUM CANNON PRESSURE GAGE.** Two or more gages are used in one test firing. In cannon using cartridge cases, the gages are placed in the bottom of the cartridge case, gas check end up or forward. In cannon using powder bags as the propellant, the gages are placed behind, or tucked under, the last powder bag, gas check end forward.

CAUTION: If properly inserted, the gages generally will not travel more than half the length of the bore, but to prevent loss, men should be stationed in appropriate positions to observe the emergence of the gages.

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Test record for 155 mm. gun.

[Officer JULIUS P. DELANY. Date Apr. 12, 1919. Metal of August 12, 1918.]

File No.....	1	2	3	4	5	6	7	8
I. C.....	28,000	28,000	28,000	28,000	28,000	28,000	28,000	28,000
Gauge No.....	3,069	1,555	3,014	2,413	2,693	3,054	5,009	1,492
I. M.....	0.3 767	0.3 774	0.3 772	0.3 774	0.3 783	0.3 776	0.3 772	0.3 770
F. M.....	0.3 392	0.3 443	0.3 463	0.3 453	0.3 403	0.3 438	0.3 420	0.3 464
Diff.....	0.0 375	0.0 331	0.0 309	0.0 321	0.0 380	0.0 338	0.0 352	0.0 306
Pressure.....	33,700	33,000	32,700	32,900	33,800	33,100	33,300	32,600
File No.....	9	10	11	12	13	14	15	16
I. C.....								
Gauge No.....								
I. M.....								
F. M.....								
Diff.....								
Pressure.....								
File No.....	17	18	19	20	21	22	23	24
I. C.....								
Gauge No.....								
I. M.....								
F. M.....								
Diff.....								
Pressure.....								
File No.....	25	26	27	28	29	30	31	32
I. C.....								
Gauge No.....								
I. M.....								
F. M.....								
Diff.....								
Pressure.....								
File No.....	33	34	35	36	37	38	39	40
I. C.....								
Gauge No.....								
I. M.....								
F. M.....								
Diff.....								
Pressure.....								
File No.....	41	42	43	44	45	46	47	48
I. C.....								
Gauge No.....								
I. M.....								
F. M.....								
Diff.....								
Pressure.....								

Test Record form No. 780

RA PD 49237

Figure 78—Test-Record Form Number 780 (Filled in for 155-mm Gun)

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES**

(3) **SMALL CANNON PRESSURE GAGE.** Only one small cannon or Navy-type small cannon gage is used in one firing because the volume occupied by two gages would increase the "density of loading" of the charge sufficiently to give erroneous pressure values. The gage is placed in the bottom of the cartridge case, gas check end up or forward.

d. Disassembling the Gage After Firing.

(1) Recover all the gages used in the test firing.

(2) Remove all fouling and other foreign matter by dipping the gages in water or CLEANER, rifle bore, and wiping them dry.

CAUTION: Do not permit this substance to remain on the hands for an appreciable length of time.

(3) Unscrew the closing cap and shake the copper cylinder and the holder out of the gage housing of one gage.

(4) Remove the holder from the cylinder. Wipe the cylinder clean and place it in the correct hole in the gage chest.

(5) Push the gas check and piston out of the gage with the gas check inserter. Wipe all parts clean and dry. Reassemble and place the gage housing in the gage chest.

(6) Carry out steps (2) to (5) above for the other gages used in the test.

NOTE: A new copper cylinder and gas check are required for each round fired.

e. Final Measurements of Cylinders. Measure the lengths of the cylinders to one ten-thousandth of an inch with the micrometer caliper, using only a moderate pressure on the knurled surface of the caliper. Record the measurements on the record form opposite F. M. (final measurements).

f. If additional rounds are to be fired, repeat the procedure described in steps a to e above. If the same gages are to be used, clean and oil the gage housing and piston before assembly as described in steps b (3), (4) and (6) above. (See par. 70 b (1) for instructions on replacing copper cylinders in pressure testing of seacoast artillery.)

66. RECORDS.

a. A pressure test record form filled in for a 155-mm gun is shown in figure 78. The data for the 155-mm gun were obtained in four firings.

b. The first four rows of the body of the table are filled in during the assembly and disassembly of the pressure gage, as described in paragraph 65 a, b and e. The fifth row "Diff." is the difference in length between the initial and final measurements. For example, the "set" of

PRESSURE GAGES

the first copper cylinder due to the powder pressure is 0.3767 minus 0.3392 or 0.0375 inch.

c. The powder pressure, sixth row, is obtained from a tarage table, similar to Table II or Table III, using the differences recorded in the fifth row of figure 78.

(1) A tarage table similar to Table II may be used provided: 1st—The table was prepared for the lot of copper cylinders from which the cylinders used in the tests were drawn. 2nd—The table was prepared for cylinders having an initial compression of 28,000 pounds per square inch. Enter the body of the tarage table with the "Diff." value, in this case 0.0375, and read the pressure in the pressure column corresponding to 0.0375. If the exact entry 0.0375 is not found in the body of the table, read the pressure corresponding to the entry closest to 0.0375. Record the pressure on the record form opposite "Pressure." Proceed in the same manner to get the pressures corresponding to the other "Diff." values.

(2) If no table such as Table II is available for cylinders having an initial compression of 28,000, it will be necessary to use a tarage table similar to Table III. Enter the column with the heading 28,000 to 36,000 and locate, if possible, an entry of 0.0375 in this column. Read the pressure in the first column corresponding to this entry and record it on the record form. If the exact entry cannot be found, get the pressure by interpolation. Thus, in the column 28,000 to 36,000, the set 0.0375 is intermediate between 0.0328 and 0.0389. Hence, the powder pressure is between 33,000 and 34,000 pounds per square inch and is equal to $33,000 + 1,000 \times (0.0375 - 0.0328) / (0.0389 - 0.0328)$ or 33,700 pounds per square inch, approximately. Record the pressure in the record form opposite "Pressure." Proceed in the same manner to get the pressures corresponding to the other "Diff." values.

67. SIGNIFICANCE OF PRESSURE DATA.

a. Proof-firing and Development of Guns and Ammunition.

(1) The maximum permissible interior pressures are specified for each gun. Hence, it is necessary to measure the powder pressure for every propellant-projectile-gun combination.

(2) The velocity and flight of a projectile depend on the powder pressure. It is customary, therefore, in developing and testing powders, to measure the powder pressures for various quantities of charge and for charges of slightly varying composition.

b. **Use of Pressure Data in the Field.** Pressure measurements are not commonly made in the field. When they are made in the field it is usually for one of the following reasons: 1st—To determine whether

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erratic firings are due to incorrect pressures. 2nd—Occasionally in test firings as an aid in obtaining a desired ballistic action in the case of guns using powder bags as the propellant. 3rd—Very occasionally, to ascertain that the ammunition-gun combination does not exceed the pressure safety limit.

68. ACCESSORIES.

a. Accessories for pressure gages include: Tools (micrometer caliper, wrenches and pliers should be cleaned and coated in a similar manner. tarage tables and handbook); gas checks; pressure cylinders; gage chest, and tin boxes for the cylinders and cylinder holders. (See figs. 75 and 77.) Only the tools specified for a particular assembly or disassembly operation should be used for that operation.

69. STORAGE.

a. For short-term storage (not exceeding one to two weeks) care should be taken that gas checks, pistons, gage housings, washers and closing caps are clean and coated with OIL, lubricating, preservative, light, before placing them in their proper places in the gage chest. For longer storage, coat with COMPOUND, rust preventive, light. The wrenches and pliers should be cleaned and coated in a similar manner. The micrometer caliper should likewise be cleaned and protected with OIL, lubricating, preventive, light, or COMPOUND, rust preventive, light, before it is placed in its case. The gage chest should be stored in a dry place.

70. PRESSURE TESTING OF SEACOAST ARTILLERY.

a. Definitions.

(1) *The elastic strength pressure* is the computed internal gas pressure in a gun which, at the section under consideration, will stress the metal in some layer of the wall tangentially up to the minimum elastic limit which is prescribed for the metal from which the member is made.

(2) *The maximum pressure* is the maximum value of the pressure exerted by the powder gases on the walls of a gun during the firing of a round.

(3) *The rated maximum pressure* for any type of gun is that value of the maximum pressure which is specified in the powder specifications as the upper limit of average pressure which may be developed by an acceptable powder in the form of propelling charges which will impart the specified muzzle velocity to the specified projectile.

(4) *The permissible mean maximum pressure* for any type of gun is that value which should not be exceeded by the average of the maxi-

PRESSURE GAGES

imum pressures developed in a series of rounds fired under any service conditions.

(5) *The permissible individual maximum pressure* for any type of gun is that value which should not be exceeded by the maximum pressure developed by any individual round under any service condition.

b. Use of Pressure Gages for Seacoast Artillery.

(1) For seacoast cannon equipped for large cannon (major caliber) pressure gages, pressure measurements will be made in all practices with service or target practice ammunition. Copper cylinders should be changed after each shot of trial fire and must be changed after completion of trial fire. Copper cylinders need not be changed between shots of record fire.

(2) For seacoast cannon using medium or minor caliber gages, pressure measurements will be limited to shots of trial fire. Extreme care will be taken after each round to insure that no gage remains in the bore.

(3) Should there be evidence that excessive pressures are being developed, the firing will be stopped and an investigation made to determine the cause.

c. **Excessive Pressures.** Excessive pressures are considered to have occurred:

(1) When the average of the maximum pressures developed in a series of rounds exceeds the *permissible mean maximum pressure*, or:

(2) When the maximum pressure developed in any individual round exceeds the *permissible individual maximum pressure*.

d. Limitations on Use of Propelling Charges.

(1) The propelling charges should not be used in a practice if in the trial shots the mean of the maximum pressure readings exceeds the permissible mean for the particular gun, or if the recorded pressure on any round exceeds the permissible individual maximum pressure, or if the difference between the maximum pressures obtained on any two rounds exceeds a value equal to 15 percent of the mean of the group. In the latter case, the powder is liable to develop dangerous pressures if firing is continued, or, if not actually unsafe, may give excessive velocity variation which will be reflected in the range dispersion.

(2) The propelling charges will not be used in subsequent practices if in the record shots the recorded pressure exceeds by more than 5 percent the *permissible individual maximum pressure*. The 5 percent increase is based upon the assumption that the coppers in the gages have not been changed between individual rounds. Under such conditions gage readings are usually somewhat higher than the pressure on any individual round.

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e. **Maximum Permissible Pressures.** Maximum permissible pressures for various cannon are listed in columns 4, 5 and 6 of Table IV. Column 3 lists the rated maximum pressure for each cannon. This pressure is listed in firing tables under the captions "Maximum pressure for which the gun is designed" or "Maximum pressure."

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71. TABLES.

GUNS

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE†	CHAMBER	
20-mm	M1 and M2, Auto.	0.963	0.990	63.08	9	0.75-in.	0.75-in. ¹	1 *
	M1916	1.555	1.575	24.25	12	1.35-in.	1.35-in. ¹	1 *
37-mm	M1A2	1.940	1.980	68.35	12	1.35-in.	1.35-in.	2 *
	M3	1.940	1.98	68.45	12	1.35-in.	1.35-in.	2 *
	M4	1.555	1.610	58.14	12	1.35-in.	1.35-in.	2 *
	M5	1.940	1.98	63.3	12	1.35-in.	1.35-in.	2 *
	M6	1.940	1.98	68.45	12	1.35-in.	1.35-in.	2 *
	M1	1.882	2.2158	76.086	16	1.35-in.	1.35-in. ¹	2 *
2.24	6 Pdr., Mk. II (Br.)	2.540	2.616	39.125	24	1.35-in.	1.35-in.	1
57-mm	M1			94.18	24	1.35-in.	1.35-in. ¹	3 *
2.95	MOUNTAIN	3.022	3.123	24.25	30	2-in.	2-in.	1 *

Table 1—Cannon Characteristics and Applicable Star Gages. See explanatory notes on page 140.

**ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES**

GUNS (Continued)

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE†	CHAMBER	
75-mm	M1897 (Fr.)	3.098	3.209	87.375	24	2-in.	2-in. ¹	2*
	M1897A1	3.098	3.209	87.375	28	2-in.	2-in. ¹	2*
	M1916 and Mods.	3.1	3.21	69.5	24	2-in.	2-in. ¹	2*
	M1917 (Br.)	3.098	3.209	69.5	24	2-in.	2-in. ¹	2*
	M1920, MI and MII	3.098	3.459	104.5	28	2-in.	2-in. ¹	3*
	M1 and M1E2	3.098	3.459	98.625	28	2-in.	2-in. ¹	3*
	M2	3.098	3.209	69.598	24	2-in.	2-in. ¹	2*
	M3	3.098	3.209	96.125	24	2-in.	2-in. ¹	3*
3	15 Pdr., M1902MI	3.408	3.906	126.00	24	2-in.	2-in. ¹	4*
	15 Pdr., M1903	3.81	4.31	137.25	24	2-in.	2-in. ¹	4*
	A. A., M1	3.408	3.906	126.00	28	2-in.	2-in. ¹	4*
	A. A., M2 and M4	3.808	4.308	137.375	28	2-in.	2-in. ¹	4*
	A. A., M3	3.408	3.906	125.83	28	2-in.	2-in. ¹	4*
	A. A., M1925MI	3.808	4.308	137.25	28	2-in.	2-in. ¹	4*
	M1917, MI and MII	3.808	4.308	137.25	28	2-in.	2-in. ¹	4*
	M1918 and MI	3.408	3.906	95.75	24	2-in.	2-in. ¹	3*
	T1	3.408	3.906	126.00	28	2-in.	2-in. ¹	4*

Table 1—Cannon Characteristics and Applicable Star Gages. See explanatory notes on page 140.

TABLES

GUNS (Continued)

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE†	CHAMBER	
90-mm	M1	4.415	4.706	152.40	32	2-in.	2-in. ¹	5*
105-mm	A. A., M3	5.420	5.806	216.67	36	2-in.	2-in. ¹	7*
4.5	M1	5.3		156.825	32	2-in.	2-in.	5*
4.7	T2	5.480	7.056	241.60	42	2-in.	2-in.	7*
6	M1897 and M1	7.0		229.75	54	2-in.; 5.75-in. ³	5.75-in.	7*; 5
	M1900	8.0 BOT 7.2		254.125	54	2-in.; 5.75-in. ³	5.75-in. ¹	8*; 6
	M1903	8.0 BOT 7.2		254.625	54	2-in.; 5.75-in. ³	5.75-in. ¹	8*; 6
	M1905	8.0		250.25	54	2-in.; 5.75-in. ³	5.75-in.	8*; 6
	M1908, M1 and MII	7.0		231.125	54	2-in.; 5.75-in. ³	5.75-in.	7*; 5
155-mm	M1917 (Fr.)	6.693		180.875	48	2-in.; 5.75-in. ³	5.75-in.	6*; 4
	M1918MI (FIL)	6.693		180.875	48	2-in.; 5.75-in. ³	5.75-in.	6*; 4
	M1920MI	6.693 BOT 7.4		230.3	80	2-in.; 5.75-in. ³	5.75-in.	7*; 5
	T3	7.4		230.00	48	2-in.; 5.75-in. ³	5.75-in.	7*; 5
	T4	7.4		230.375	48	2-in.; 5.75-in. ³	5.75-in.	7*; 5
	M1A1			230.567	48	2-in.; 5.75-in. ³	5.75-in.	7*; 5

Table 1—Cannon Characteristics and Applicable Star Gages. See explanatory notes on page 140.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES

GUNS (Continued)

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE†	CHAMBER	
8	M1888 and MI	9.5		201.375	48	5.75-in.	5.75-in. ¹	6
	M1888 and MII	9.5		201.25	48	5.75-in.	5.75-in. ¹	6
	Mk. V, Mod 1 (Navy)	9.5		281.5	48	5.75-in.	5.75-in. ¹	7
	Mk. VI, Mod. 3A1 and 3A2 (Navy)	9.5 x 11	8.504	281.5	64	5.75-in.	5.75-in. ^{1,2}	7
	T2			328.15	64	5.75-in.	5.75-in. ¹	8
10	M1888, A1 and MIIA1	11.8		271.25	60	5.75-in.	5.75-in. ^{1,2}	7
	M1895	11.8		280.37	60	5.75-in.	5.75-in. ^{1,2}	7
	M1895, MI	11.8		278.75	72	5.75-in.	5.75-in. ^{1,2}	7
	M1900	13.75	BOT 12.0	326.5	90	5.75-in.	5.75-in. ^{1,2}	8
	M1888, MI, MII ¹ / ₂ and MII	14.2		328.75	72	5.75-in.	5.75-in. ¹	9
12	M1895, A1 and A2	14.2		337.75	84	5.75-in.	5.75-in. ¹	9
	M1895M1, M1A1 and M1A2	14.2		336.125	84	5.75-in.	5.75-in. ¹	9
	M1900	16.5	BOT 14.5	391.25	72	5.75-in.	5.75-in. ²	10
	M1918	15.3	BOT 14.5	487.625	72	5.75-in.	5.75-in. ²	12
	M1907 and MI	16.8		399.825	126	5.75-in.	5.75-in. ^{1,2}	10
14	M1909	16.8		464.625	92	5.75-in.	5.75-in. ^{1,2}	11
	M1910 and MI	16.8		464.625	92	5.75-in.	5.75-in. ^{1,2}	11
	M1919	16.8		464.625	92	5.75-in.	5.75-in. ^{1,2}	11
	M1920MI and MII	16.5		597.25	136	5.75-in.	5.75-in. ²	13
	Mk. IV, M1	16.5	BOT 15.5	597.875	126	5.75-in.	5.75-in. ²	13

Table 1—Cannon Characteristics and Applicable Star Gages. See explanatory notes on page 140.

TABLES

GUNS (Continued)

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE †	CHAMBER	
16	M1895	19.0		447.0	96	5.75-in.	5.75-in. ²	12
	M1919, MII and MIII	22.0 BOT	19.0	667.375	96	5.75-in.	5.75-in. ^{1,2}	15
	Mk. II, M1 (Navy)	18.5 BOT	17.5	674.5	96	5.75-in.	5.75-in. ^{1,2}	15
HOWITZERS								
75-mm	Pack, MI, M1A1 and M2A1	3.130	3.209	35.75	28	2-in.	2-in. ¹	1*
105-mm	M2A1	4.235	4.356	78.02	36	2-in.	2-in. ¹	2*
155-mm	M1917, A1 and A2	6.260		67.5	48	2-in.; 5.75-in. ³	5.75-in. ¹	2*; 1
	M1918 (SCH)	6.260		68.386	48	2-in.; 5.75-in. ³	5.75-in. ¹	2*; 1
	M1920	6.693		112.75	48	2-in.; 5.75-in. ³	5.75-in.	4*; 3
	T1	6.693		112.875	48	2-in.; 5.75-in. ³	5.75-in.	4*; 3
	M1	6.693		113.1	48	2-in.; 5.75-in. ³	5.75-in.	4*; 3
8	M1920 and MI	8.5		164.6	72	5.75-in. ⁴	5.75-in.	4
	Mk. VI M'17 (US)	8.5		102.0	48	5.75-in.	5.75 in. ^{1,2}	3
	Mk. VI (Br)	8.5		102.0	48	5.75-in.	5.75-in. ^{1,2}	3
	Mk. VII (Br)	8.5		102.0	48	5.75-in.	5.75-in. ^{1,2}	3
	Mk. VIII ¹ / ₂ (US)	8.5		99.5	48	5.75-in.	5.75-in. ^{1,2}	3
	M1			164.8	64	5.75-in.	5.75-in.	4

Table 1—Cannon Characteristics and Applicable Star Gages. See explanatory notes on page 140.

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT,
IMPRESSION OUTFITS AND PRESSURE GAGES

HOWITZERS (Continued)

CALIBER	MODEL OF CANNON	CHAMBER DIAMETERS (BOT = BOTTLENECK)		INCHES FROM MUZZLE FOR GAGING	NO. OF LANDS	APPLICABLE LEVER-TYPE STAR GAGE		NO. OF EXTENSION TUBES
		MIN.	MAX.			BORE †	CHAMBER	
240-mm	M1918 and Mods. T1	9.823		156.25 276.76	84 68	5.75-in. 5.75-in.	5.75-in. ¹ 5.75-in.	4 6
16	M1920	19.0		335.0	96	5.75-in.	5.75-in. ¹	8

MORTARS

60-mm	M2	2.392				2-in.		0
81-mm	M1	3.205				2-in.		1*
12	M1890 and M1	12.5		95.5	72	5.75-in.	5.75-in. ^{1,2}	3
	M1908	12.5		95.5	108	5.75-in.	5.75-in. ^{1,2}	3
	M1912	12.5		153.75	108	5.75-in.	5.75-in. ^{1,2}	4

EXPLANATORY NOTES FOR TABLE I

- *36-inch staves. 50-inch staves are also available.
- †Measuring point with spacing washer used for measurements of grooves.
- ¹Measuring point with spacing washer used for measurement of chamber.
- ²Measuring point with distance piece used for measurement of chamber.
- ³The 2-inch star gage will generally be used. The 5.75-inch gage can be used if a special 3-inch minimum diameter head is available.
- ⁴Measuring point with distance piece used for measurement of grooves.

TABLES

TARAGE TABLE FOR CANNON PRESSURE CYLINDERS

[Metal of August 12, 1918. Annealed November 15, 1918. Mean length, 0.3351.
Piston area one-tenth square inch.]

34,000.....	0.0000	38,000.....	0.0238	42,000.....	0.0462	46,000.....	0.0681
100.....	.0006	100.....	.0244	100.....	.0468	100.....	.0686
200.....	.0012	200.....	.0249	200.....	.0473	200.....	.0691
300.....	.0018	300.....	.0255	300.....	.0479	300.....	.0697
400.....	.0024	400.....	.0261	400.....	.0484	400.....	.0702
500.....	.0030	500.....	.0267	500.....	.0490	500.....	.0707
600.....	.0036	600.....	.0272	600.....	.0496	600.....	.0712
700.....	.0042	700.....	.0278	700.....	.0501	700.....	.0717
800.....	.0048	800.....	.0284	800.....	.0507	800.....	.0723
900.....	.0054	900.....	.0289	900.....	.0512	900.....	.0728
35,000.....	.0060	39,000.....	.0295	43,000.....	.0518	47,000.....	.0733
100.....	.0066	100.....	.0301	100.....	.0524	100.....	.0738
200.....	.0072	200.....	.0306	200.....	.0529	200.....	.0744
300.....	.0078	300.....	.0312	300.....	.0535	300.....	.0749
400.....	.0084	400.....	.0317	400.....	.0540	400.....	.0754
500.....	.0090	500.....	.0323	500.....	.0546	500.....	.0760
600.....	.0096	600.....	.0329	600.....	.0552	600.....	.0765
700.....	.0102	700.....	.0334	700.....	.0557	700.....	.0770
800.....	.0108	800.....	.0340	800.....	.0563	800.....	.0775
900.....	.0114	900.....	.0345	900.....	.0568	900.....	.0781
36,000.....	.0120	40,000.....	.0351	44,000.....	.0574	48,000.....	.0786
100.....	.0126	100.....	.0357	100.....	.0579	100.....	.0791
200.....	.0132	200.....	.0362	200.....	.0585	200.....	.0797
300.....	.0138	300.....	.0368	300.....	.0590	300.....	.0802
400.....	.0144	400.....	.0373	400.....	.0596	400.....	.0807
500.....	.0150	500.....	.0379	500.....	.0601	500.....	.0813
600.....	.0156	600.....	.0384	600.....	.0606	600.....	.0818
700.....	.0162	700.....	.0390	700.....	.0612	700.....	.0823
800.....	.0168	800.....	.0395	800.....	.0617	800.....	.0828
900.....	.0174	900.....	.0401	900.....	.0623	900.....	.0834
37,000.....	.0180	41,000.....	.0406	45,000.....	.0628	49,000.....	.0839
100.....	.0186	100.....	.0412	100.....	.0633	100.....	.0844
200.....	.0192	200.....	.0417	200.....	.0639	200.....	.0849
300.....	.0197	300.....	.0423	300.....	.0644	300.....	.0855
400.....	.0203	400.....	.0428	400.....	.0649	400.....	.0860
500.....	.0209	500.....	.0434	500.....	.0655	500.....	.0865
600.....	.0215	600.....	.0440	600.....	.0660	600.....	.0870
700.....	.0221	700.....	.0445	700.....	.0665	700.....	.0875
800.....	.0226	800.....	.0451	800.....	.0670	800.....	.0881
900.....	.0232	900.....	.0456	900.....	.0676	900.....	.0886
38,000.....	.0238	42,000.....	.0462	46,000.....	.0681	50,000.....	.0891

Table II

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

TARAGE TABLE FOR CANNON PRESSURE CYLINDERS

(Corrected for compressions made at Frankford Arsenal)

F. A. Drawing No. 7233.

For use with pressure gage $\frac{1}{16}$ square inch piston.

Metal of August 12, 1918

Mean diameter .2525

Purchase Order No. 1680

Annealed November 15, 1918

Mean length .5000

Work Order 19 S 72

Pure Copper

Sub Order 10

Pressure per sq in. on sq in. piston	Mean corrected total sets	Mean Corrected Partial Sets												
		6,000 to 12,000	9,000 to 21,000	12,000 to 18,000	14,000 to 20,000	18,000 to 27,000	20,000 to 28,000	24,000 to 32,000	26,000 to 34,000	28,000 to 36,000	30,000 to 38,000	32,000 to 40,000	36,000 to 45,000	40,000 to 50,000
6,000	.0096	.0000												
7,000	.0130	.0034												
8,000	.0167	.0071												
9,000	.0205	.0109	.0000											
10,000	.0247	.0151	.0042											
11,000	.0290	.0194	.0085											
12,000	.0338	.0242	.0133	.0000										
13,000	.0388		.0183	.0050										
14,000	.0439		.0234	.0101	.0000									
15,000	.0493		.0288	.0155	.0054									
16,000	.0548		.0343	.0210	.0109									
17,000	.0603		.0398	.0265	.0164									
18,000	.0659		.0454	.0321	.0220	.0000								
19,000	.0715		.0510		.0276	.0056								
20,000	.0772		.0567		.0333	.0113	.0000							
21,000	.0830		.0625			.0171	.0058							
22,000	.0889					.0230	.0117							
23,000	.0947					.0288	.0175							

ORDNANCE MAINTENANCE—STAR-GAGING EQUIPMENT, IMPRESSION OUTFITS AND PRESSURE GAGES

TABLE OF PRESSURES

1	2	3	4	5	6
	Computed Elastic Strength- Pressure psi	Rated Maximum Pressure psi	Permissible Mean Max. Pressure psi	Permissible Individual Max. Press. psi	Permissible* Max. Press. Record Shots psi
GUNS	6" Gun M1897MI	49800	38000	41000	45600
	6" Gun M1908	55330	38000	41000	45600
	6" Gun M1908MI	55330	38000	41000	45600
	6" Gun M1908MII	55330	38000	41000	45600
	6" Gun M1900	51000	38000	41000	45600
	6" Gun M1903	58462	38000	41000	45600
	6" Gun M1905	55401	38000	41000	45600
	7" Gun Mk. II (Navy)	66500	35600	38400	42700
	8" Gun M1888	52000	38000	41000	45600
	8" Gun M1888MI	52000	38000	41000	45600
	8" Gun M1888MII	52000	38000	41000	45600
	8" Gun Mk. VI Mod. 3 (Navy)	50000	37000	40000	44400
	8" Gun Mk. VI Mod. 3A1 and 3A2	53000	38000	41000	45600
	10" Gun M1888	53000	38000	41000	45600
	10" Gun M1888MI	53000	38000	41000	45600
	10" Gun M1888MII	53000	38000	41000	45600
	10" Gun M1888MIIA1	53000	38000	41000	45600
	10" Gun M1895	52300	38000	41000	45600
	10" Gun M1895MI	52300	38000	41000	45600
	10" Gun M1900	51000	32000	34600	38400

*Pressure recorded by a series of rounds without changing coppers.

TABLES

12" Mortar M1890	50200	37000	40000	42600	44400
12" Mortar M1890MI	50200	37000	40000	42600	44400
12" Mortar M1908	53080	37000	40000	42600	44400
12" Mortar M1912	61464	37000	40000	42600	44400
12" Gun M1888	52998	38000	41000	43700	45600
12" Gun M1888MI	52998	38000	41000	43700	45600
12" Gun M1888MI-1/2	52998	38000	41000	43700	45600
12" Gun M1888MII	52998	38000	41000	43700	45600
12" Gun M1895	52304	38000	41000	43700	45600
12" Gun M1895MI	52304	38000	41000	43700	45600
12" Gun M1895MIA1 and MIA2	52304	38000	41000	43700	45600
12" Gun M1900	52000	30000	32400	34500	36000
14" Gun M1907	54914	38000	41000	43700	45600
14" Gun M1907MI	53963	38000	41000	43700	45600
14" Gun M1909	55511	38000	41000	43700	45600
14" Gun M1910	54900	38000	41000	43700	45600
14" Gun M1910MI	54900	38000	41000	43700	45600
14" Gun M1920MI	49843	38000	41000	43700	45600
14" Gun M1920MII	49843	38000	41000	43700	45600
16" How. M1920	53200	38000	41000	43700	45600
16" Gun M1895	52900	38000	41000	43700	45600
16" Gun M1919	58784	38000	41000	43700	45600
16" Gun M1919MII	58784	38000	41000	43700	45600
16" Gun M1919MIII	58784	38000	41000	43700	45600
16" Gun Mfk. II Mod. 1 (Navy)	50500	38000	41000	43700	45600

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72. STANDARD NOMENCLATURE LISTS.

- a. Cleaning and preserving materials.....SNL K-1
- b. Measuring, impression, testing and reconditioning
outfitsSNL N-9

Current Standard Nomenclature Lists are as tabulated
here. An up-to-date list of SNL's is maintained as
the "Ordnance Publications for Supply Index".....OPSI

73. EXPLANATORY PUBLICATIONS.

- a. Cleaning, preserving and lubricating materials.....TM 9-850
- b. Maintenance of materiel in the hands of troops.....OFSB 4-1
- c. Technical Manuals (TM's), Technical Regulations
(TR's) and Ordnance Field Service Technical Bul-
letins (OFSTB's) pertaining to the cannon to be star
gaged.
- d. "Elements of Ordnance" by T. J. Hayes, John Wiley
and Sons, Inc., 1938.
- e. "Naval Ordnance" by Officers of the U. S. Navy, U. S.
Naval Institute. Annapolis, Md., 1939.

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(For explanation of symbols, see FM 21-6)

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